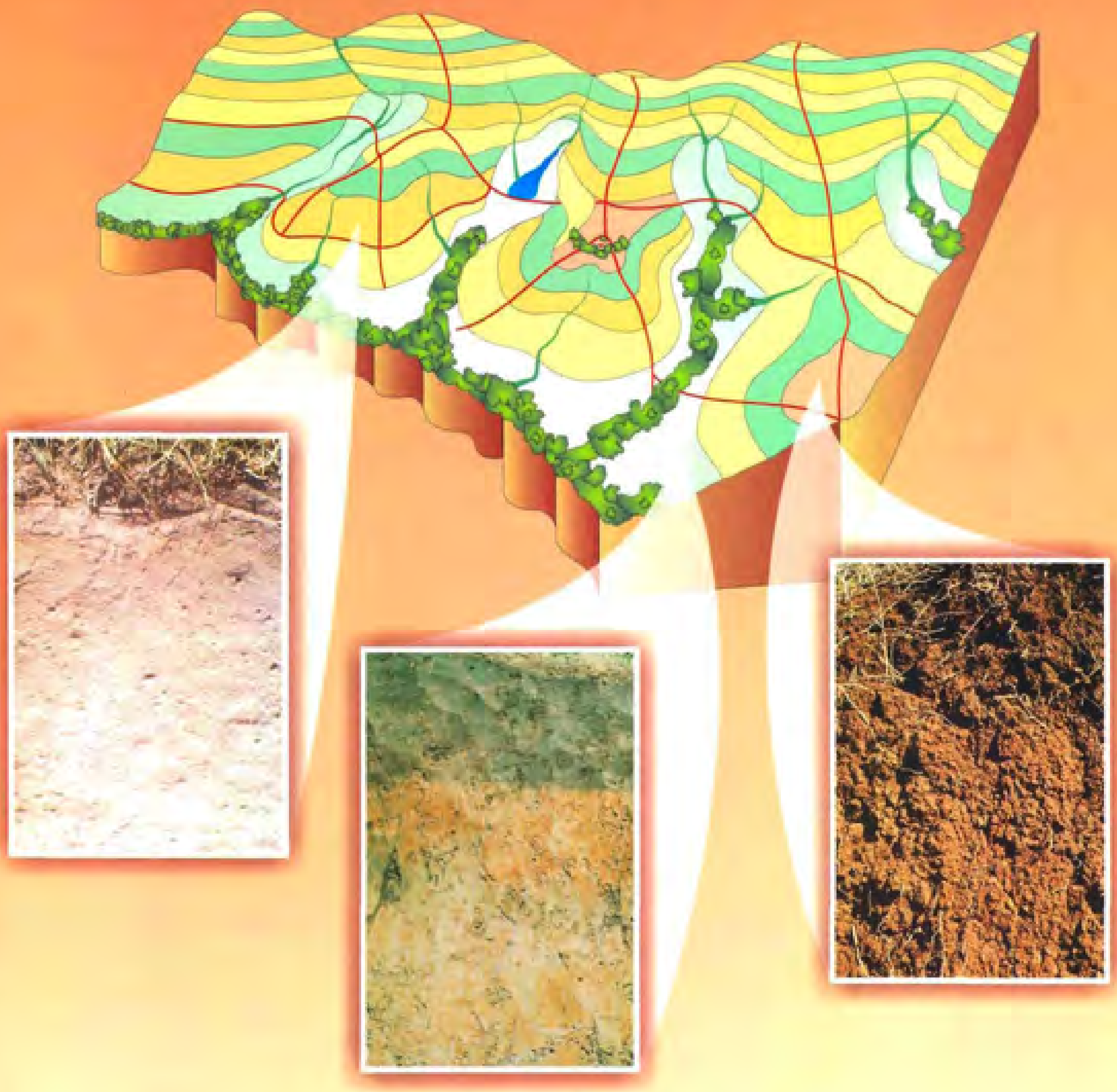
IDENTIFICATION & MANAGEMENT OF THE SOILS OF THE SOUTH AFRICAN SUGAR INDUSTRY



SOUTH AFRICAN SUGARCANE RESEARCH INSTITUTE
Unlocking the potential of sugarcane

IDENTIFICATION AND MANAGEMENT OF THE SOILS OF THE SOUTH AFRICAN SUGAR INDUSTRY

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FOREWORD

Knowing the soils that occur on a sugarcane farm and understanding how and why they differ will assist growers in deciding how to manage the crop more effectively under different soil bioclimatic conditions and help to increase farm productivity and profitability in harmony with environmental issues. Cane grows well on good soils with relatively little management, but greater knowledge is required of the many poor soils in the sugar industry if they are to be conserved and managed in the best way possible.

This publication first appeared in 1973, as *Soils of the Sugar Industry, Bulletin No. 19.* The second edition, published in 1984, introduced the national binomial system of classifying South African soils. Since then, our knowledge of soils of the sugar industry has increased substantially. This third edition of the Experiment Station Soils Bulletin has been considerably revised and is designed to provide a practical guide on how to identify, name and manage the more common soils that occur in the industry. Several new soil forms have been identified and where appropriate soil families have been introduced into the system in line with the publication, *Soil Classification – A Taxonomic System for South Africa* (published by the Institute for Soil, Climate and Water (formerly Soils and Irrigation Research Institute), 1991). Soil families are a new class falling between the soil form and the soil series.

Although the names of soil systems have been changed, this new edition also retains the old method of classification based on parent material and soil series, as in many instances the soil type may be identified merely by using the parent material key. In addition, useful new sections on the soil and a range of soil management practices in regard to sugarcane, have been included.

We are indebted to Dr BE Beater for laying the foundations for classifying soils at the series level in the South African sugar industry, and to the Director of the Institute for Soil, Climate and Water of the Agricultural Research Council, for permission to use photographs and diagrams which originally appeared in their publication *Soil Classification - A Taxonomic System for South Africa* (1991). The following publications were also used as important sources of information in compiling the soils section of this bulletin:

- Some characteristics of the soils of the sugarcane growing areas around Malelane-Komatipoort, Eastern Transvaal, by EA von der Meden and RR Maud. Published in the Proceedings of the South African Sugar Technologists' Association Congress, 1966.
- Soil Series of the Natal Sugar Belt, by Dr BE Beater, published by the South African Sugar Association in 1970.
- The use of land characteristics in crop science with particular reference to the South African sugar industry, by CN MacVicar. Published in the Proceedings of the South African Sugar Technologists' Association Congress, 1969.
- An integrated system for soil identification in the South African sugar industry, by JH Meyer. Published in the Proceedings of the South African Sugar Technologists' Association Congress, 1984.
- Soils: a management factor in sugarcane production in the South African sugar industry, by JH Meyer and PK Moberly. Published in the Proceedings of the South African Sugar Technologists' Association Congress, 1984.

Finally, we are grateful to the following members of the Soils Bulletin Working Group for their valuable contributions:

Messrs F Botha, GF Buchanan, QV Mann, D McArthur, JH Meyer,
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THE SOIL

SOIL COMPOSITION

Soil is the thin porous mantle covering most of the terrestrial parts of the globe. Where climate permits, it supports plant life and stores water. Along with sunlight, air and water, soil is one of the vital ingredients of sustainable agricultural production. Soil modifies the effect of climate by influencing the amount of runoff and the portion of rainfall retained in the root zone and released to the plant. Soils also determine the rates of fertiliser application due to their different nutrient supplying and immobilising characteristics.

Soil consists of rock fragments (less than two millimetres in cross section), finely weathered minerals (particularly clay), soluble nutrients, organic matter, humus, live bacteria, fungi, algae, air spaces and water. Soil is vastly different from crushed or finely powdered rock. The main differences are due largely to the presence of clay, organic matter, humus and soil microbes, and the increased porosity and water holding capacity associated with these.

SOIL FORMATION

The weathering of rocks to form soil can be arbitrarily divided into physical, chemical and biological agencies. Physical agents tend to be more important than chemical agents in dry and/or very cold climates. Chemical weathering is more important in hot and wet climates. Biological agents will act in either physical or chemical directions, e.g. the roots of a wild fig tree could force their way into a rock crevice and physically break the rock open, or they could exude a chemical solvent that will erode the rock.

1. Physical agents

- Raindrop splash causing abrasion of the surface and particle dispersal.
- Sand or rock fragments in streams and rivers causing abrasion, e.g. round, water-worn boulders.
- Wind – causing abrasion by a sandblasting effect.
- Temperature changes causing expansion and contraction which results in exfoliation or onion skin weathering of rocks.
- Alternate wetting and drying causing either downward leaching or upward movement of soluble salts as a result of capillary water movement and evaporation.
- Transportation and grading – both wind and water can move soil particles long distances and, in the process, there is usually a sifting and sorting of materials into different particle sizes.

2. Chemical agents

- Oxidation, e.g. iron changing into rust.
- Reduction, e.g. available nitrate nitrogen (NO_3) being reduced under waterlogged conditions ultimately to elemental nitrogen gas.
- Carbonation, e.g. dissolved carbon dioxide combining with calcium or magnesium ions to form free lime deposits or nodules in the soil.
- Hydration, e.g. red ochre and yellow ochre are both different degrees of hydrated ferric iron oxide. Yellow ochre has more water attached to the molecule than red ochre.

3. Biological agents

- Burrowing macro-fauna such as earthworms and moles.
- Plant roots squeezing into rock crevices.
- Microbial degradation of plant and animal waste.
- Man, with ploughs, rippers, bulldozers, fertiliser, irrigation, drainage works, etc.

All these weathering processes act in association with one another and continue long after the soil has been formed. Even in well developed soils the weathering process continues, so it is never completely static. As old soil is eroded off the surface, so new soil is formed in the soil profile.

SOIL DEVELOPMENT

Soils are formed as a result of weathering but the character, or nature, of the soil is affected by a number of soil development factors. These include:

1. Parent material
2. Climate
3. Drainage and topography
4. Age and erosion
5. Living organisms.

If these factors are identical in two places, no matter how far apart they are, the sites will be occupied by identical soils. If there is a difference in one or more of these factors (say, a lower rainfall or a south-west aspect) then different soils may develop. Soils are a product of their environment. Some of the main differences in the soil forming factors are described below.

1. Parent material

The underlying parent material is one of the most important factors responsible for differences in soils on the coastal plain and lowveld of KwaZulu-Natal, Swaziland and Mpumalanga.

- Often very different soils are found adjacent to each other, and since climate, drainage, topography, age, erosion and living organisms have all had similar effects, under these conditions the only other factor likely to be different is parent material. However, the same parent material in different climatic zones can result in very different soils.
- The most common soil and rock forming mineral is quartz (silicon dioxide or sand), which occurs as the dominant mineral in all sandstone rocks, acid igneous rocks, and light textured soils.
- Feldspars (pink, white or grey silicates of Al, K, Na and Ca) occur in granite as a secondary mineral to quartz together with micas (clear, brown, green or black silicates of Al, K, Mg and Fe).
- Clay is a mineral formed in the soil and is an end product of weathering of a variety of aluminium silicates. Kaolinite, montmorillonite and illite are the predominant clay minerals in sedimentary shale and most heavy textured soils.
- The type and proportion of minerals, together with their crystal size, determines the nature of the parent material.

The main parent materials present and their extent in the South African sugar industry are given in Appendix 1 (page 152).

2. Climate

Climate acts in many ways but can only have an influence on soils over thousands of years, so climate and soil age are therefore often associated. The following are some examples of climatic influence on soil development.

- Tropical moist climates speed up the rate of chemical weathering and cause the development of deep, porous, leached, acid soils.
- Cold climates slow down the rate of chemical weathering, causing shallower soils, even to the prevention of soil development under continuous ice.
- Cool humid climates cause a build-up of organic matter.
- Dry climates, resulting in evaporation in excess of precipitation, cause soluble salts and nutrients to accumulate in surface soils.

3. Drainage and topography

- Soils in and around valley floors or gentle slopes not only receive moisture from precipitation, but also from deep percolation and seepage from well drained soils above. These soils are said to be hydromorphic (water formed). They frequently display waterlogged, mottled, clay subsoils (G horizons) or an eluviated (bleached or washed out) layer, called an 'E horizon'.
- In the southern hemisphere, northerly and westerly aspects are hotter than southerly and easterly aspects. In KwaZulu-Natal, northerly and westerly aspects are often in a rain shadow, whereas south-easterly slopes face the

cool rain bearing winds. Northerly aspects therefore tend to develop shallower soils, black or red in colour, and have greater structural development, whereas southerly slopes often have deeper soils, brown or yellow in colour with apedal structure.

- Soils on steep escarpments may have such a high rate of erosion that bare rock has been exposed, whereas soils on gentle slopes may be several metres deep and completely free from rocks or boulders.

4. Age and erosion

Soils are formed (a) over tens of thousands of years from the weathering of underlying bedrock or (b) from transported materials such as alluvial deposits or wind-blown sand dunes which may have been laid down recently due to floods or windstorms.

Underlying rock below a soil blanket may weather to form new soil at an estimated rate of half a millimetre per year and, if this was balanced by a natural rate of erosion also at half a millimetre of soil loss per year, then soil formation and erosion would be said to be in equilibrium. One metre of soil might be supposed to be 2 000 years old, two metres to be 4 000 years old, etc. However, this is not the case because of a process called 'eluviation'.

- **Eluviation** is the process whereby fine soil particles, particularly clay, are washed down through the soil profile between the larger particles. Sandstone may have only 1% of its mass capable of being weathered to form clay, yet, in a mature residual soil derived from this rock, there may be up to 35% clay in the subsoil. This clay has been washed out of the topsoil (**eluviation**) and accumulates in the subsoil (**illuviation**) over many thousands of years. Such a soil would be said to be mature and well developed.
- **Young, immature soils** are usually found on steep slopes, sand dunes and alluvial plains. They are also associated with high rates of natural erosion, low clay content (particularly if derived from sandstone or acidic rocks), shallow depth, grey colours and stratification.
- **Mature, well developed soils** are associated with flat topography, old land surfaces, low rates of natural erosion, increased clay content in the subsurface horizons, deep well drained horizons and red or yellow colouration.
- **Accelerated erosion** in the sugar belt often speeds up natural erosion a hundred-fold or more (e.g. in the 1987 September floods many cane lands in KwaZulu-Natal lost more than 8 mm of soil, or over 100 tons per hectare, in only three days). Half a millimetre of soil represents 6-7 tons per hectare, and the natural rate of regeneration of soils is often less than 10 tons of soil per hectare per annum.

5. Living organisms

These are the same agents causing biological weathering, but their effects on soil development are many and varied.

- Topsoil is often stained a dark colour by humus and organic matter which has important physical and nutritional properties.
- The decomposition of plant material produces substances which may dissolve or translocate other mineral constituents.
- Soil macro-organisms (e.g. earthworms and moles) can redistribute material either within the soil profile or over short distances on the land surface.

In the sugar belt, the clay content of many soils on old termitaria (termite mounds or 'iziduli') may be as high as 40%, while the clay content of the soils between these mounds may be as little as 10%. Termites drain the soil beneath their nests, causing deeper and more complete weathering.

It is the combined effects of all these weathering processes, the geological upheavals and the soil developing factors that have resulted in the extremely variable soils found in the sugar industry.

SOIL WATER

- Water in soils is stored in the pores between soil particles. If the **total pore space (TPS)** is filled with water the soil is **saturated**.
- When water is allowed to drain from the soil a point is reached where free drainage is negligible. This point is called **field capacity (FC)** and further soil water loss is either via **evaporation** or **transpiration** by plants.

- Plants extracting water reach a point where temporary stress is experienced at midday with average temperature and wind speed. **Freely available water (FAW)** is the amount of soil water between this point and field capacity, and beyond this point yield losses can be expected.
- Where soil water is depleted to the point where no more can be extracted by the plant, this is called **permanent wilting point (PWP)**.
- The amount of soil water between field capacity and permanent wilting point is called **available water capacity (AWC) and is measured in millimetres per metre (mm/m)**.
- **Total available water (TAW), measured in millimetres,** is the **AWC** multiplied by the **effective rooting depth (ERD)** of a particular soil.

Factors affecting available water capacity

- **Soil texture** – **AWC** generally increases with an increase in clay content of up to about 40%, after which it generally decreases with increase in clay content.
- **Surface cover** – Trash or tops are effective in reducing surface evaporation after rain or irrigation. Other advantages are reduction of surface crusting, runoff and erosion, coupled with an increase in water infiltration.
- **Soil depth** – Affects the amount of water that can be stored, while **effective rooting depth (ERD)** may be limited by hard rock, a plough pan or the presence of a water table.
- **Soil compaction** – Total volume of pores is reduced in compacted soils, leaving less space for water and soil air. Also at **FC** the ratio of water to air is less favourable, and **PWP** occurs at a higher soil water content. The overall effect is to reduce **AWC**.

SOIL NUTRIENTS

- Sugarcane acquires most of its nutrients and water from the soil by absorption through the roots.
- Apart from carbon, hydrogen and oxygen, 14 other elements are important for crop growth:

  Major elements: nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, chlorine, silicon.
  Minor elements: boron, copper, iron, manganese, molybdenum, zinc.

- Amounts of major nutrients removed by the above-ground parts of the plant vary considerably depending on where the cane is grown, whether the crop is rainfed or irrigated, and the soil fertility status. For example, removal by variety NCo376:

  12 month rainfed plant crop (Shakaskraal) = 168 kg N, 18 kg P, 214 kg K, 46 kg Ca, 55 kg Mg
  12 month irrigated plant crop (Pongola) = 276 kg N, 29 kg P, 790 kg K, 74 kg Ca, 64 kg Mg.

Soil factors influencing rate of nutrient availability

Exchange capacity

- Clay and organic matter particles in the soil are chemically very active and able to adsorb and exchange elements such as calcium, magnesium and potassium by a process called **exchange capacity**.
- Soils with a high exchange capacity can store plenty of nutrients which are gradually released into the soil solution from which plant roots can absorb them.

Clay minerals

- The predominant clay minerals present are often very different from one soil to another.
- For this reason **reddish-brown ferralitic soils** and **heavy black clays (vertisols)** exhibit quite different properties, as shown in the table below.

Ferralitic soils	Vertisols
Clay mineral – kaolinite	Clay mineral – montmorillonite
Little swelling when wet	Strongly swelling when wet
Low adsorption capacity	High adsorption capacity
Strongly weathered	Less strongly weathered
Highly porous and strongly leached	Often waterlogged and lacking aeration
Develop in acid environment	Develop in slightly acid to alkaline environment

Soil pH

Can influence crop production in **three** ways:

- Directly by the effect of hydrogen ion concentration in the soil on plant nutrient uptake.
- Indirectly by its effect on availability of major or minor elements.
- By allowing a build-up of toxic ions such as aluminium and manganese, which restrict plant growth.

The second and third aspects are the most important for sugarcane as several essential elements such as copper, manganese and zinc tend to become less available as soil pH increases from 5,0 to 7,5 (see Figure 1, Appendix 4, page 160).

Availability of major nutrients

Nitrogen (N)

- Primary source of soil N is the **atmosphere**. Gains in N occur through fixation of elemental N by micro-organisms, and ammonia and nitrates in rainfall. Losses occur through crop removal, leaching, volatilisation and denitrification.
- An internal cycle operates in the soil by which mineral or available N becomes **immobilised by microbial action** and is incorporated into soil organic matter during decay of plant residues.
- The amount of immobilised N subsequently **remineralised** for crop use varies with different soils and is related to the level of response obtained to applied fertiliser N (see Appendix 4, page 160).

Potassium (K)

- Most potassium in the soil exists in inorganic forms, the majority of which are unavailable to plants.
- Up to 48 000 kg per hectare furrow slice of total K are not uncommon, although the quantity of K held at any one time that is easily available rarely exceeds 2% of total K.
- Soil potassium can be divided into **three** fractions:
  1. K as an element in soil minerals (very slowly available).
  2. K held in an exchangeable form by soil colloids such as clay minerals and organic matter (slowly available).
  3. K present in the soil solution (readily available).

Phosphorus (P)

- Compared with potassium, total phosphorus in a soil is much lower and most of it is unavailable to plants.
- Soluble sources of P applied to soils as fertiliser are often fixed and are thus unavailable to plants even under ideal conditions.
- Soil phosphorus can also be divided into **three** fractions:
  1. Very slowly available (reserves).
  2. Slowly available.
  3. Readily available (water soluble and exchangeable).
- Ratio of replenishment from the very slowly and slowly available P fractions is much less than with the corresponding fractions for K.

ORGANIC MATTER

Soil organic matter is formed from residues of plants, soil organisms and animal remains. This ranges from undecayed plant and animal tissues to relatively stable humus. Organic matter plays an important role in the following soil functions:

- improves soil structure and tilth
- supplies soil nutrients especially nitrogen, phosphorus and sulphur
- improves **cation exchange capacity (CEC)** and pH buffering capacity of the soil
- increases soil water holding capacity, and resistance to compaction
- binds soil particles together thus reducing erosion
- encourages build-up of soil micro-organisms, which assist in breakdown of herbicides and other plant toxins.

The level of organic matter in soil depends on the soil type and is also an indication of the health or well-being of the soil. Organic matter has a high N content and lesser amounts of other nutrients. All nutrients in organic matter are unavailable to plants until the organic matter is broken down into inorganic forms by mineralisation. The amount of N released from organic matter alone is usually insufficient for profitable cane production, and must be supplemented with synthetic fertilisers or animal manures.

SOIL CLASSIFICATION

INTRODUCTION

Methods of identifying soils

A wide spectrum of soils occurs within the South African sugar industry and these differ greatly in their properties. The simplest method of classifying soil is by a description of colour, texture and other features such as:

- red and grey medium-grained sands
- black, heaving clays which are occasionally saline
- shallow grey sandy loams on steeply sloping land
- dark alluvial soils
- neutral red clays
- wet gley soils (clayey or sandy) occurring in valley bottoms
- moderate to very acid, porous red and yellow soils, some aluminous and/or humic.

Differences between these types of soils can be attributed to the parent materials from which they have formed and the environmental (rainfall, temperature, topography, drainage) and biological conditions under which they have developed. The length of time that the parent materials have been exposed to the combined actions of these environmental factors or weathering processes, and the rate of erosion are also important.

The soil parent material method

In the past, a soil was characterised by referring only to its parent material and geographical locality. This was because soil scientists who first worked on soils of the South African sugar industry found a very strong relationship between the parent rocks and the soils derived from them. Dolerite always weathered to form heavy, deep red or shallow black clays. Shales and Dwyka tillite usually produced shallow, fine grained soils, while granite yielded coarse, abrasive, sandy loam soils. The soils were therefore classified according to the underlying parent material and nearly the whole industry has been mapped in this way to a scale of 1:6 000. The type and extent of soil parent materials that have been mapped in the South African sugar industry are shown in Appendix 1, page 152. Individual soil series were also described and named after the farm or locality where they were first found. This remains a very practical and easy way of recognising groups of soils with strong geological ties.

The binomial classification

The introduction of the binomial system of classification by the Department of Agriculture and Fisheries in 1977, provided a means of classifying soils without reference to the soil parent material. In this system, there are two categories: a general one of soil forms and a more specific one of soil series. The general category comprised 41 soil forms, each made up of a vertical sequence of diagnostic top and subsoil horizons. There were five topsoil and 15 subsoil horizons, each clearly defined in terms of soil properties. A thorough understanding of the definitions of these horizons is required for their identification. Each form was subdivided into a number of series which had in common the prescribed horizon sequence of that particular form. They differed in some of their properties, mainly texture and base status. A total of 504 series were formally recognised.

In 1984 the Experiment Station published the second edition of the Soils Bulletin. This described the 33 soil forms and 130 soil series known to occur in the sugar industry. In many ways the binomial system of classifying soils is analogous to that used by botanists and zoologists to classify plants and animals according to their genus and species. Thus soils are classified by allocating them first to the appropriate soil form and then to the series. A number of soil series belonging to the same soil form are therefore like a family of soils.

In 1991, the second edition of *'Soil Classification – A Taxonomic System for South Africa'* was published. This introduced 10 more diagnostic subsurface horizons, a number of new soil forms, and a category called the 'soil family' between the soil form and the soil series.

This third edition of *'Soils of the Sugar Industry'* makes reference to all the diagnostic horizons likely to occur in the sugar industry (five topsoil and 20 subsurface horizons) and identifies 49 of the most commonly occurring soil forms, 42 new families and 158 soil series.

Soil system classification

In the 1970s a broader grouping of soil associations was developed at the Experiment Station, known as the Soil System Classification. This grouped the different soils of geographical regions, climatic zones and differently aged land surfaces. In this third edition of the Soils Bulletin, the system classification is retained but the names of the distinctive areas have been replaced by simpler descriptive phrases. The new descriptions of the soil systems are given in Appendix 2, and the maps on pages 13 to 20.

The integrated approach

Although the soil parent material and binomial methods of identifying soils are treated separately in this bulletin, there is considerable merit in using both methods to identify soils. The **soil parent material key** provides a shortlist of the most likely soil forms, and the soil series associated with each form may subsequently be identified from tables. Examination of the soil profile using the **binomial classification** criteria for diagnostic horizons will enable identification of the soil form. Soil series and/or soil family are then identified from tables.

THE SOIL PARENT MATERIAL METHOD

PROCEDURE

If you have a soil parent material map of your farm from the Experiment Station, proceed as follows:

Step 1: Identify the parent material of the soil that you wish to identify, using the colour code index on the farm map.

Step 2: Identify the soil system of your farm from the maps shown on pages 13 to 20.

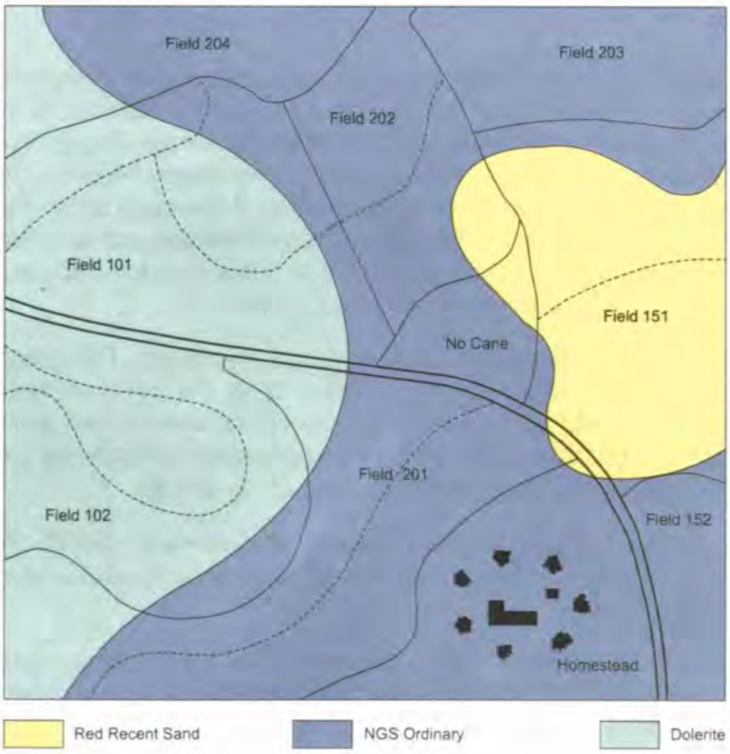
Step 3: Obtain a simple profile description from a freshly exposed face in a test pit, trench or road cutting.

Step 4: Having identified the soil parent material and the soil system, now select the appropriate soil form from the shortlist in the 'Parent material key to the soil forms' (see pages 21 to 28) that most closely matches the profile description you have prepared.

Step 5: Turn to the page containing the colour plate of the soil form you identified and, using various criteria such as soil system, texture, grade of sand and colour, select the appropriate series or family name from the table.

Step 1 : Identifying the soil parent material

Most farms in the sugar industry have been surveyed to a 1:6 000 scale and each parent material has a different colour coding on the farm map. The maps are housed at the Experiment Station and copies are available for a nominal fee. A replica of a typical soil parent material map is shown below. To identify the parent material of a particular field, it must first be located on the farm map and the main colour identified. For example, from the map shown here, fields 101 and 102 would be classifield as being mainly Dolerite, whereas 151 is Red Recent Sand and 201 is Natal Group Sandstone (Ordinary). The colour codes that represent each parent material are listed in Appendix 1 (page 152).



Step 2 : Identifying the soil system for your farm

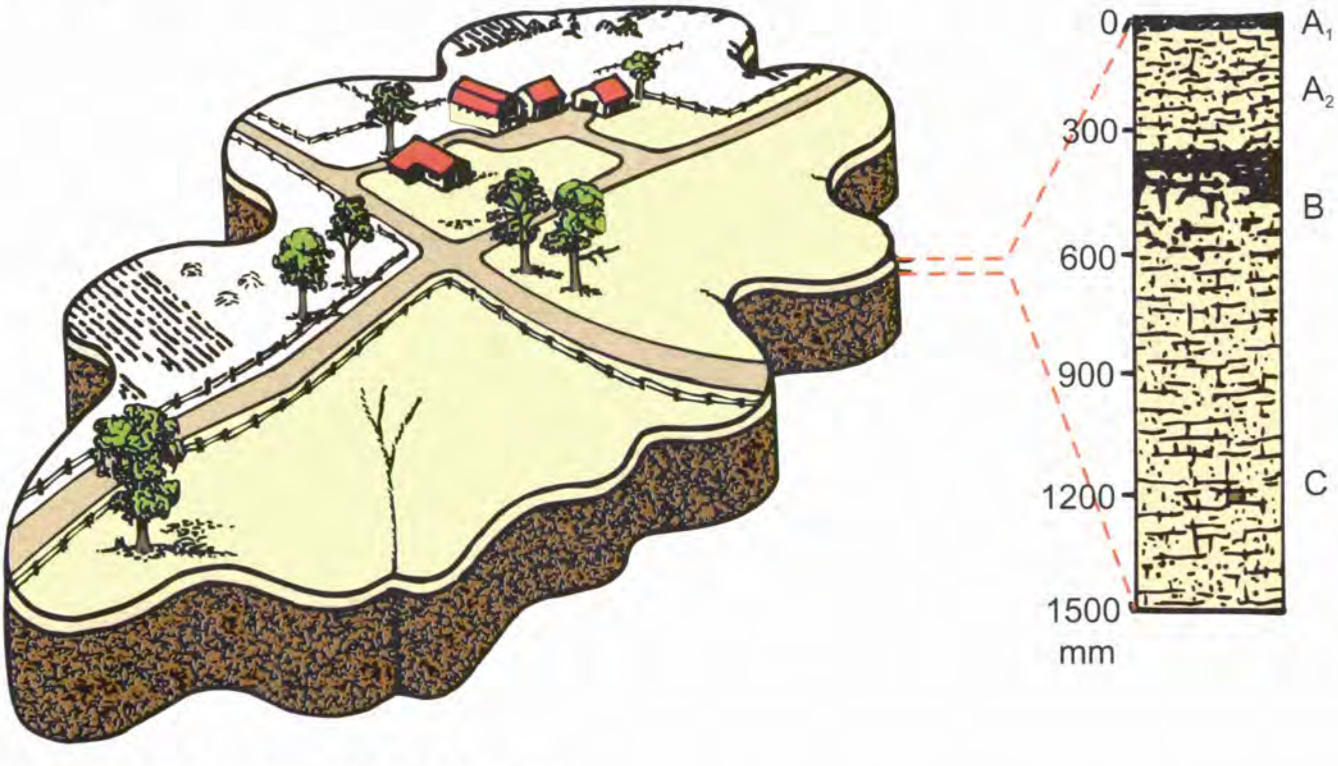
The distribution of soils in the sugar industry is not related to soil parent material alone but also to other factors. A soil system refers to an association of soils that coincide with geographical areas of similar climate, topography and age of the land surface. Seven systems have been described. These are:

- Coastal Sands System
- Coastal Lowlands System
- River Valley System
- Hinterland System
- Mistbelt System
- Dry Lowveld System
- Humid Lowveld System.

The distribution of these soil systems is shown in the accompanying set of coloured maps which facilitate easy identification of the system for any farm. In general, the northern irrigated areas comprise mainly the Dry and Humid Lowveld systems, while the rainfed areas of KwaZulu-Natal fall into the other five systems. The main features of each system in terms of climate, altitude and soil physical properties are summarised in Appendix 2 (page 155).

Step 3 : Obtaining a simple soil profile description

When the soil parent material and the soil system have been identified the next step is to determine the nature of the soil on the site. This means determining important properties such as colour, depth, texture and structure (see Appendix 3, page 156). This is best carried out by exposing the soil profile, either by digging a pit or clearing a soil face in an adjacent road cutting or ditch. Usually two or more distinct layers will be observed and these are referred to as horizons.



Step 4 : Selecting the soil form

Once the parent material, soil system and appearance of the soil profile have been established, the soil form that best matches the description of the profile can be selected from the shortlist in the parent material key that follows.

Step 5 : Selecting the soil series or family

Turn to the page containing the relevant form and select the appropriate soil series or family from the table which appears below the colour plate. Useful information on the physical and chemical characteristics of the identified soil series or families can be obtained from the two tables on the page facing the soil form colour plate.

Examples

Soils in two cane fields (101, 102) of the farm XYZ situated in the Kwa Dukuza (Stanger) area require identification. The soil parent material map (see map) shows both fields to be colour coded mainly green.

Field 101

Step 1:	Parent material	:	Dolerite
Step 2:	Soil system	:	Coastal Lowlands
Step 3:	Profile description	:	deep, red, structured clay
Step 4:	From parent material key	:	Shortlands form (see pages 88-89)
Step 5:	From soil series table	:	Shortlands series

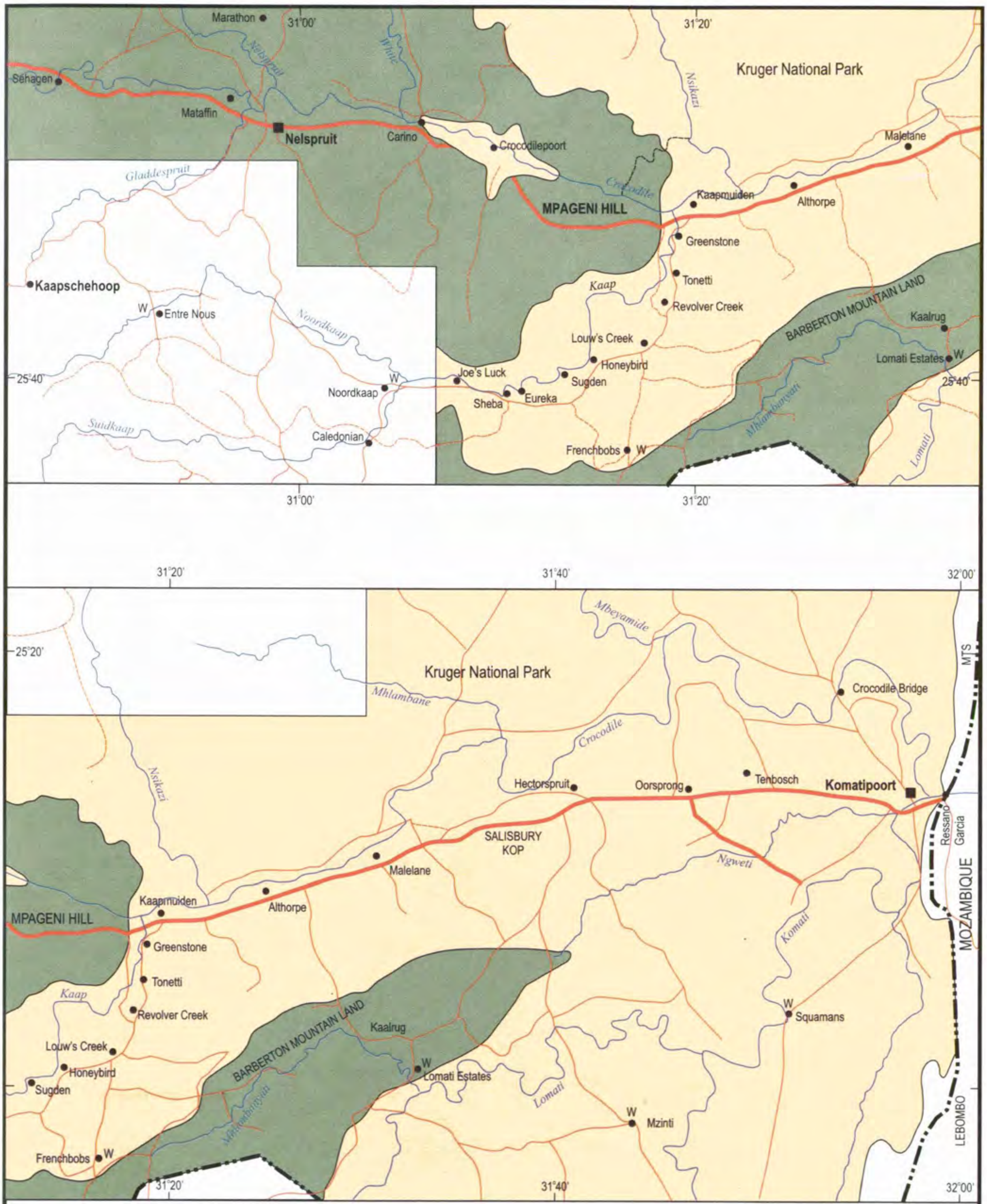
Field 102

Step 1:	As above		
Step 2:	As above		
Step 3:	Profile description	:	shallow, red or black, cracking, blocky clay on any well drained material
Step 4:	From parent material key	:	Arcadia form (see pages 52-53)
Step 5:	From soil series table	:	Rydalvale series

Having identified a particular soil, more information about it is presented in the sections that follow and in the tables opposite the colour plate.

For example, the Sprinz series in the Inanda form (see pages 46-47) has a very high available water capacity, good drainage and high N mineralising capacity but is very strongly P-fixing. A general guide on how to interpret these properties is given in Appendices 3 and 4, on pages 156 and 160 respectively.

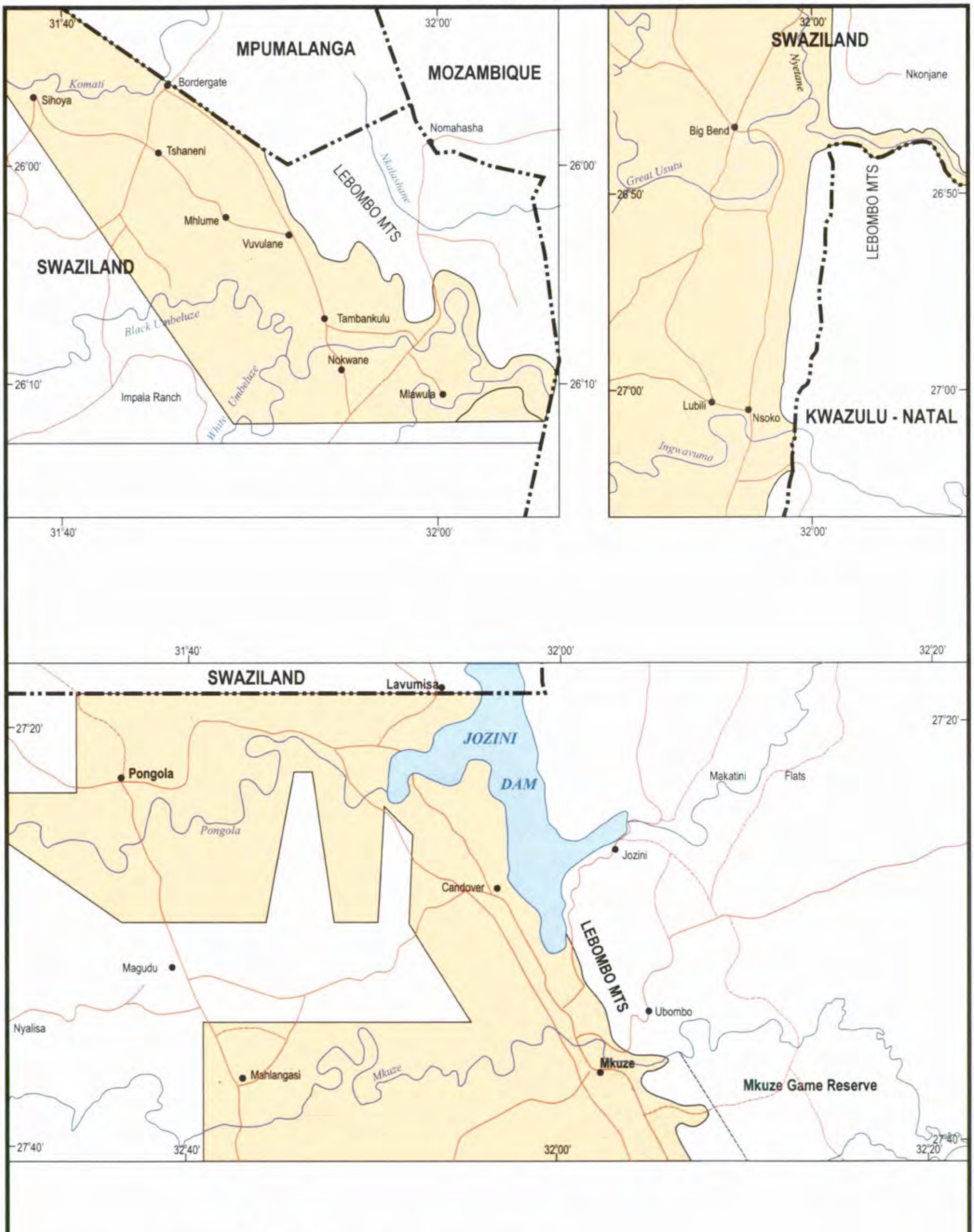
Mpumalanga



LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Dry Lowveld	Warm arid	Weakly weathered soils, some with lime	< 380
Humid Lowveld	Warm subhumid	Moderately weathered, without lime	> 300

Swaziland - Pongola - Mkuze



LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Dry Lowveld	Warm arid	Weakly weathered soils, some with lime	< 380

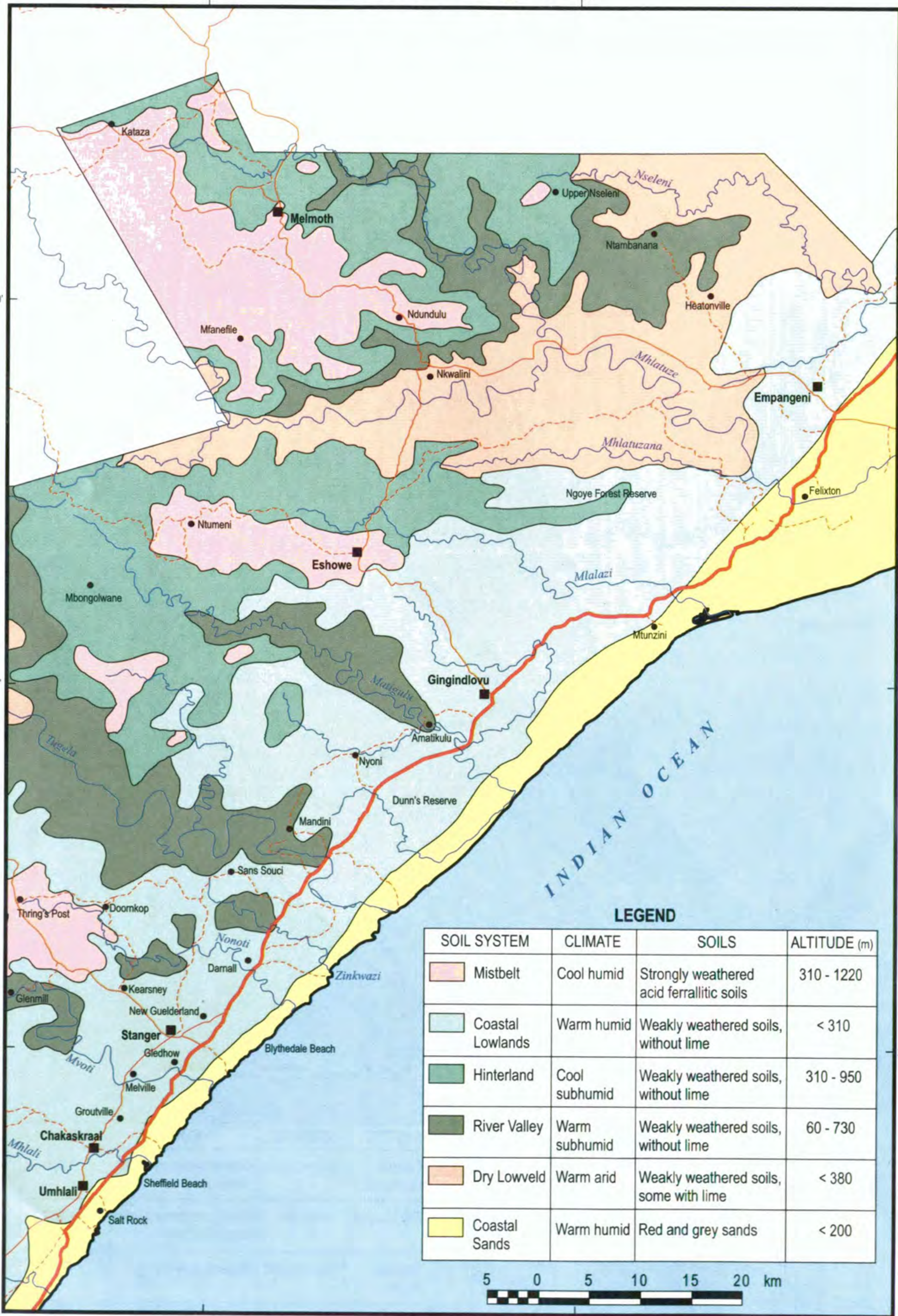
5 0 5 10 15 20 km

Hluhluwe - Empangeni

LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Dry Lowveld	Warm arid	Weakly weathered soils, some with lime	< 380
Coastal Sands	Warm humid	Red and grey sands	< 200

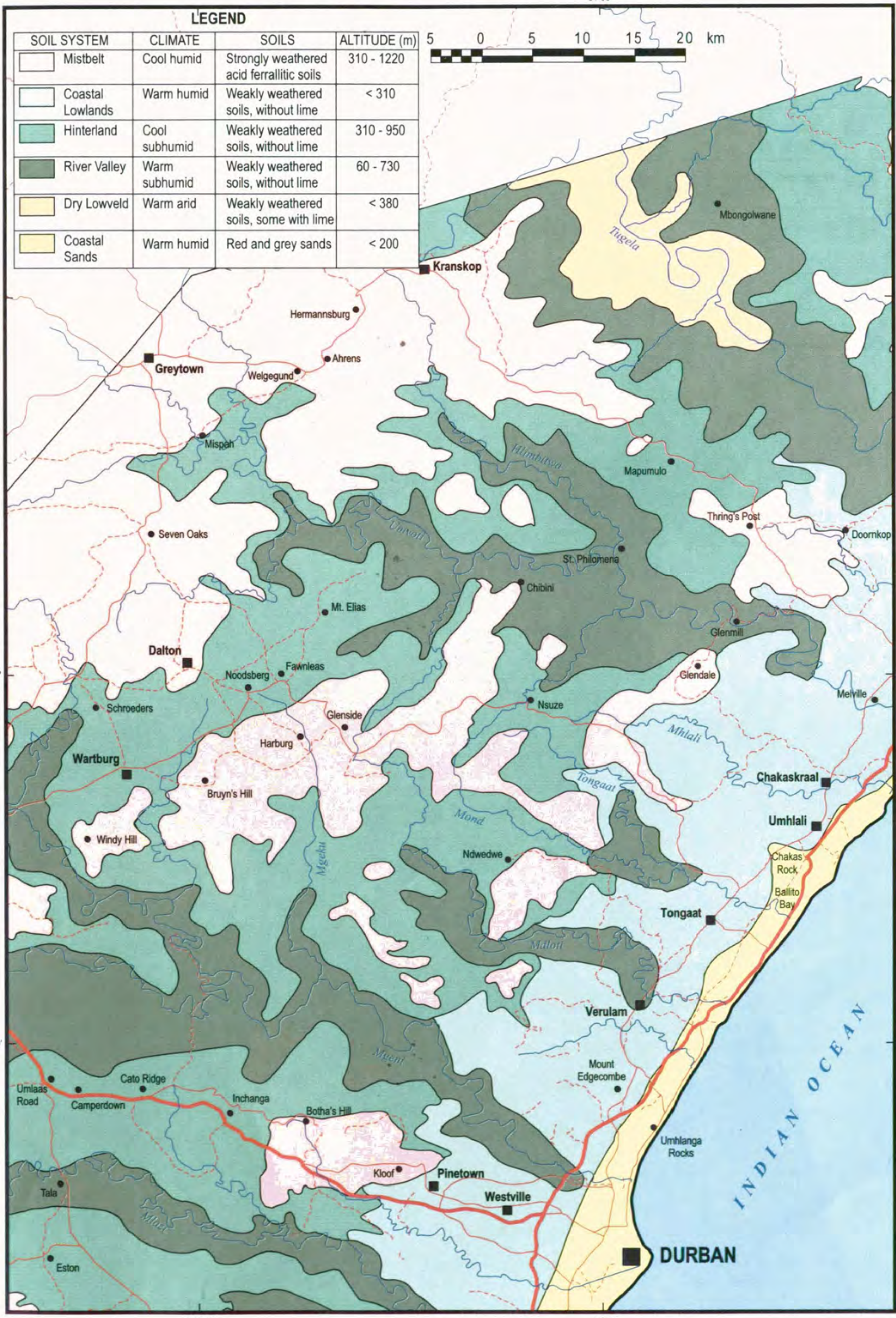
Melmoth - Tongaat



LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Mistbelt	Cool humid	Strongly weathered acid ferrallitic soils	310 - 1220
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Hinterland	Cool subhumid	Weakly weathered soils, without lime	310 - 950
River Valley	Warm subhumid	Weakly weathered soils, without lime	60 - 730
Dry Lowveld	Warm arid	Weakly weathered soils, some with lime	< 380
Coastal Sands	Warm humid	Red and grey sands	< 200

Kranskop - Umlaas Road - Durban

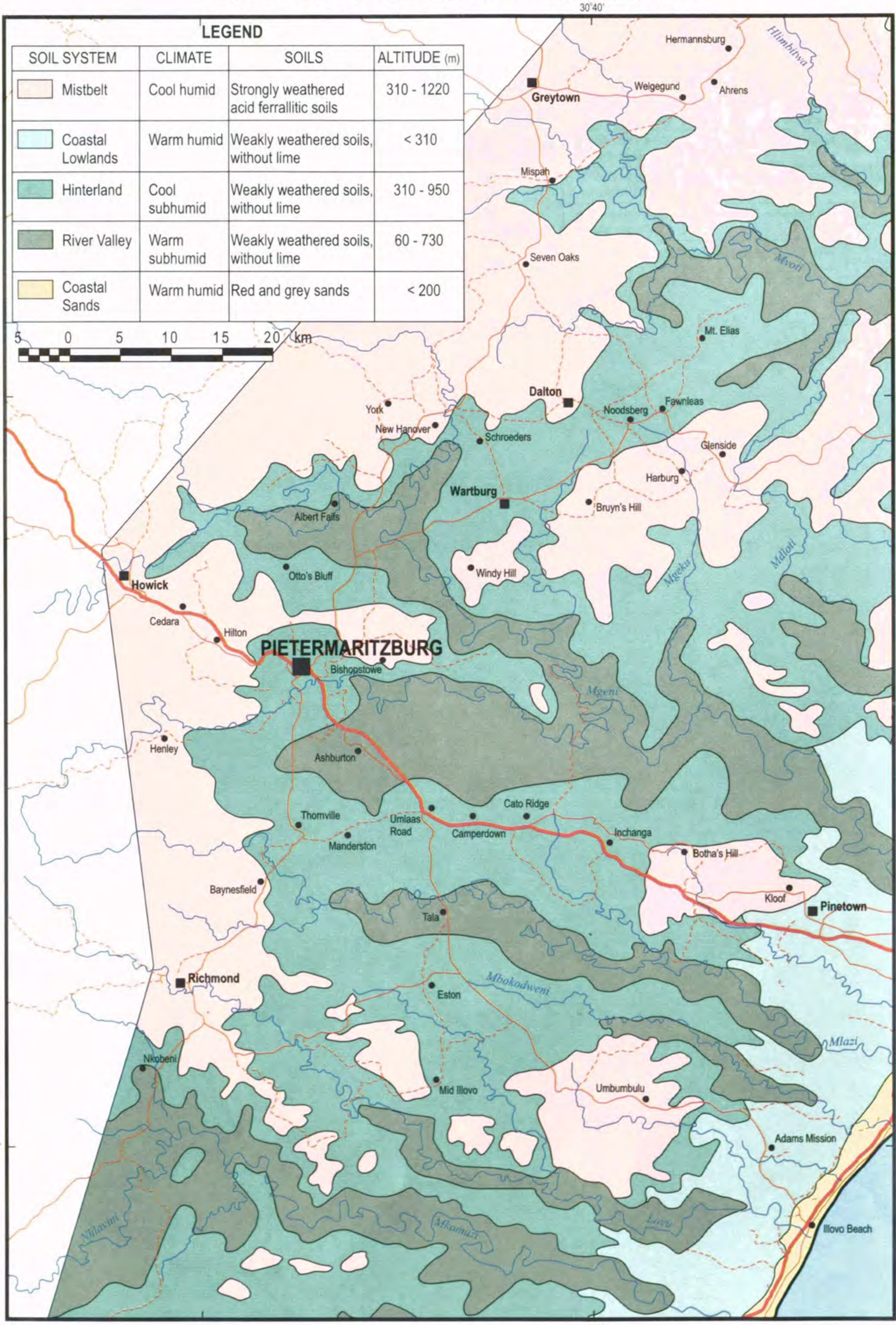


SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Mistbelt	Cool humid	Strongly weathered acid ferrallitic soils	310 - 1220
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Hinterland	Cool subhumid	Weakly weathered soils, without lime	310 - 950
River Valley	Warm subhumid	Weakly weathered soils, without lime	60 - 730
Dry Lowveld	Warm arid	Weakly weathered soils, some with lime	< 380
Coastal Sands	Warm humid	Red and grey sands	< 200

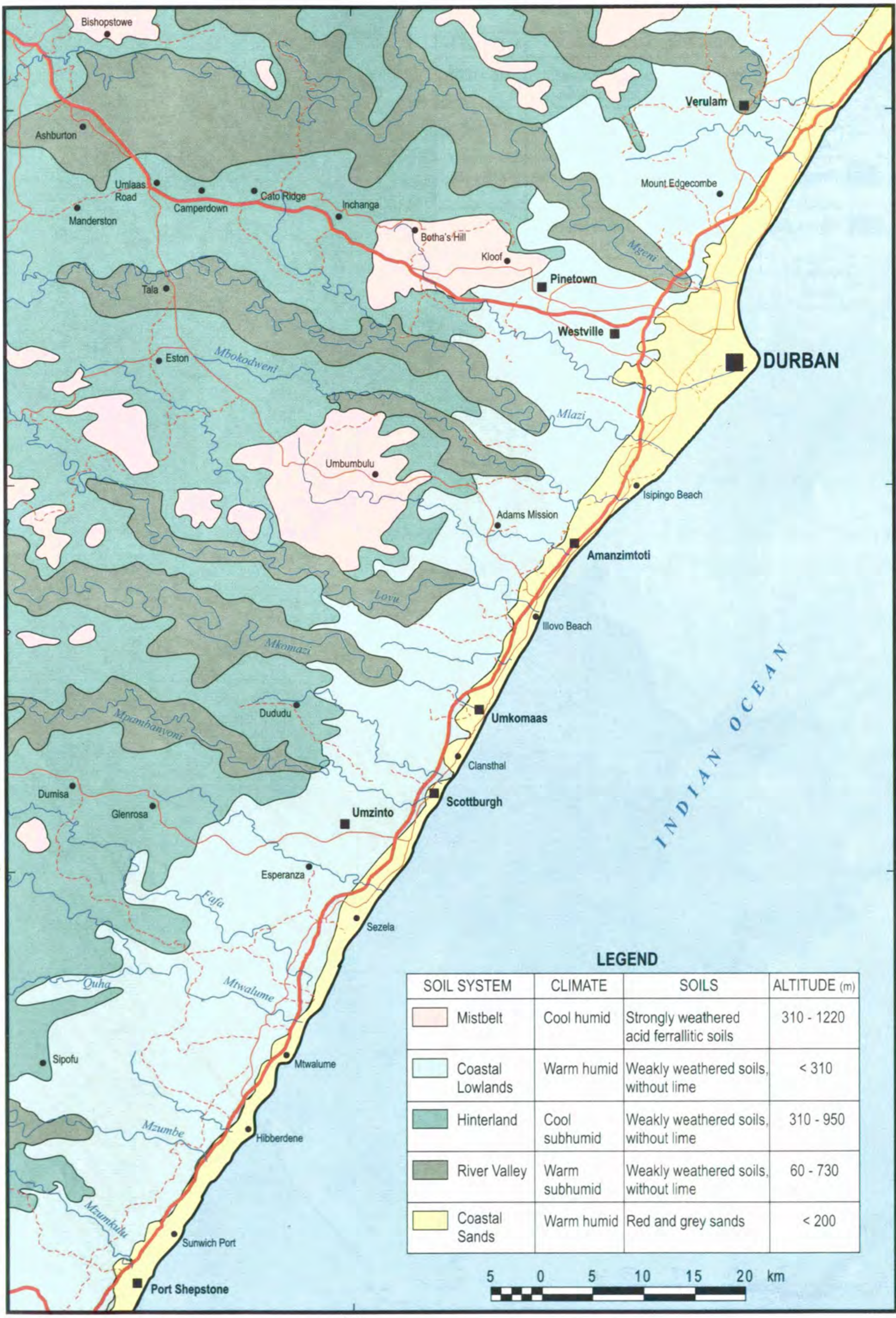
Seven Oaks - Richmond - Umbumbulu

LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Mistbelt	Cool humid	Strongly weathered acid ferrallitic soils	310 - 1220
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Hinterland	Cool subhumid	Weakly weathered soils, without lime	310 - 950
River Valley	Warm subhumid	Weakly weathered soils, without lime	60 - 730
Coastal Sands	Warm humid	Red and grey sands	< 200



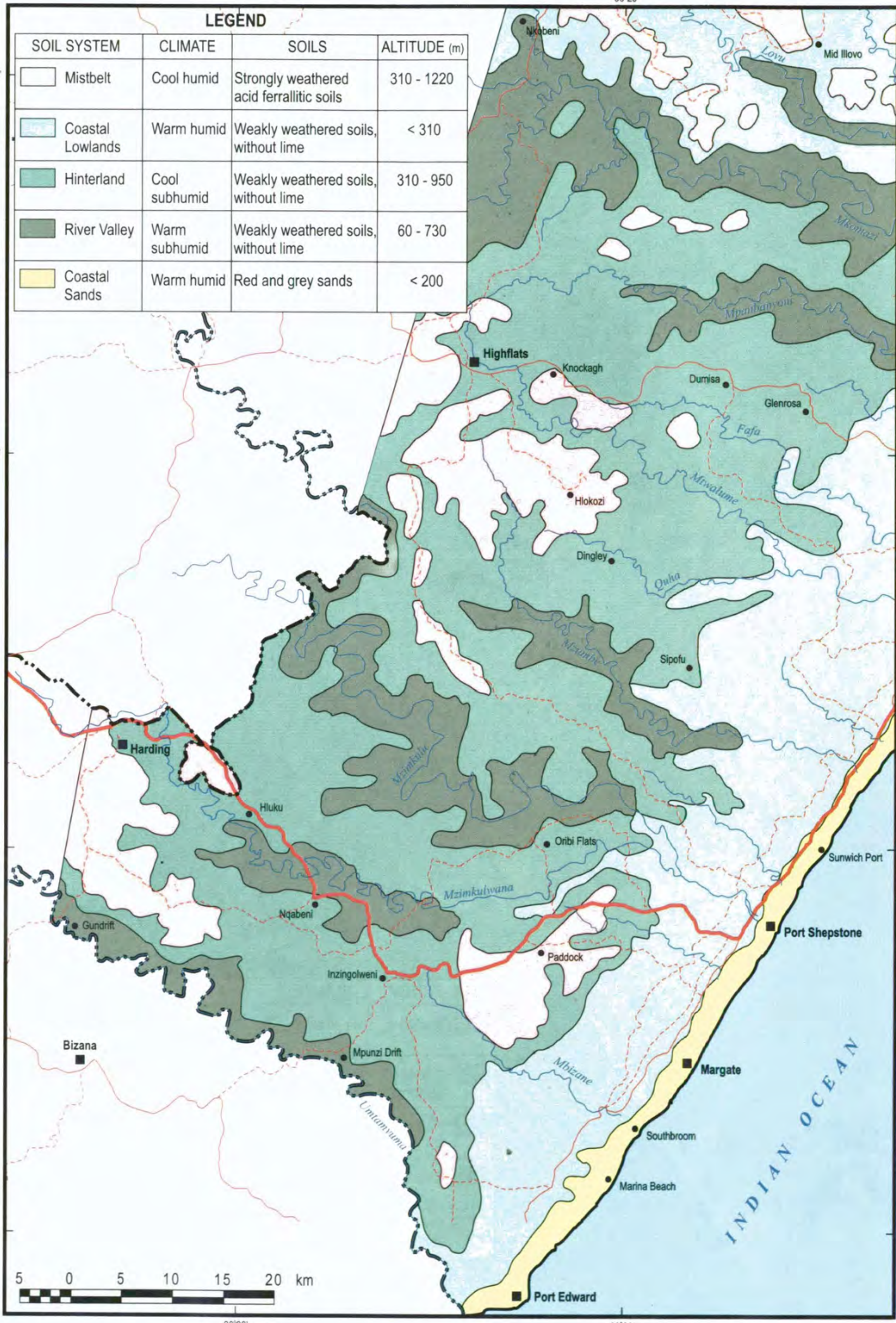
Durban - Mid-Illovo - Margate



LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Mistbelt	Cool humid	Strongly weathered acid ferrallitic soils	310 - 1220
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Hinterland	Cool subhumid	Weakly weathered soils, without lime	310 - 950
River Valley	Warm subhumid	Weakly weathered soils, without lime	60 - 730
Coastal Sands	Warm humid	Red and grey sands	< 200

Highflats - Harding - Port Edward



LEGEND

SOIL SYSTEM	CLIMATE	SOILS	ALTITUDE (m)
Mistbelt	Cool humid	Strongly weathered acid ferrallitic soils	310 - 1220
Coastal Lowlands	Warm humid	Weakly weathered soils, without lime	< 310
Hinterland	Cool subhumid	Weakly weathered soils, without lime	310 - 950
River Valley	Warm subhumid	Weakly weathered soils, without lime	60 - 730
Coastal Sands	Warm humid	Red and grey sands	< 200

PARENT MATERIAL KEY TO THE SOIL FORMS

1. SWAZILAND BASIC ROCKS

DRY AND HUMID LOWVELD SYSTEMS		Pages
Red or black cracking clays:		
shallow cracking clay on any well drained material	Arcadia	52-53
heavy cracking waterlogged clay subsoil (bottomland)	Rensburg	54-55
Red clays:		
deep blocky structured clay	Shortlands	88-89
deep non-structured clay loam	Hutton	90-91
deep non-structured clay loam on soft plinthite	Bainsvlei	94-95
Black blocky structured clays:		
non-cracking clay on hard rock (upland)	Milkwood	58-59
non-cracking clay with tongues of subsoil into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope)	Bonheim	64-65
yellow mottled waterlogged clay subsoil (bottomland)	Willowbrook	66-67
Grey non-structured clays:		
shallow soil on hard rock (upland)	Mispah	68-69
grey or dark topsoil with tongues of subsoil into weathering rock	Glenrosa	74-75

2. AMPHIBOLITE

COASTAL LOWLANDS, RIVER VALLEY AND HINTERLAND SYSTEMS		
Black blocky structured clays:		
shallow, non-cracking clay on hard rock (upland)	Milkwood	58-59
with tongues of subsoil into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope)	Bonheim	64-65
yellow mottled waterlogged clay subsoil (bottomland)	Willowbrook	66-67

3. PRE-GRANITE QUARTZITE

ANY SYSTEM EXCEPT COASTAL SANDS AND MISTBELT		
Grey sand:		
shallow soil on hard rock (upland)	Mispah	68-69
grey or dark topsoil with tongues of subsoil into weathering rock	Glenrosa	74-75
subsoil contains light bleached horizon with tongues into rock	Cartref	118-119

4. TUGELA SCHIST

COASTAL LOWLANDS AND RIVER VALLEY SYSTEMS		
Red:		
shallow red-brown cracking clay on any well drained material	Arcadia	52-53
deep blocky structured clay	Shortlands	88-89
deep non-structured clay loam	Hutton	90-91
deep non-structured clay loam on soft plinthite	Bainsvlei	94-95
Black:		
shallow cracking clay on any well drained material	Arcadia	52-53
non-cracking blocky clay with tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope)	Bonheim	64-65
non-cracking blocky clay on mottled clay (bottomland)	Willowbrook	66-67
heavy cracking waterlogged clay subsoil (bottomland)	Rensburg	54-55

5. GRANITE

ANY SYSTEM EXCEPT COASTAL SANDS AND MISTBELT

Grey coarse sandy loams:

upland		
shallow loam with tongues into weathering rock	Glenrosa	74-75
subsoil contains light bleached horizon with tongues into rock	Cartref	118-119
lower slope (mainly Lowveld Systems)		
vertically structured heavy clay subsoil	Sterkspruit	86-87
subsoil contains bleached sand on vertically structured clay	Estcourt	124-125
bottomland		
subsoil contains bleached sand on hard plinthite	Wasbank	116-117
subsoil contains bleached sand on soft plinthite	Longlands	114-115
subsoil contains bleached sand on mottled clay (usually wet)	Kroonstad	110-111
yellow mottled waterlogged subsoil	Katspruit	108-109

Black blocky loams:

non-cracking blocky clay subsoil with clay tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope)	Bonheim	64-65
blocky clay on yellow mottled clay (bottomland)	Willowbrook	66-67

Red gritty loams:

non-structured porous loam	Hutton	90-91

6. NATAL GROUP SANDSTONE (NGS)

MISTBELT SYSTEM

NGS (Mistbelt)

Dark brown fluffy humic loams:

shallow subsoil with clay tongues into rock	Nomanci	40-41
deep non-structured orange/red subsoil	Inanda	46-47
deep non-structured yellow over red subsoil	Kranskop	50-51
deep non-structured yellow subsoil	Magwa	48-49
deep weakly structured variegated subsoil with clayskins	Sweetwater	42-43

NGS (Ordinary)

Dark grey loams:

brown clayey subsoil with clay tongues into weathering rock (upland)	Glenrosa	74-75
yellow non-structured subsoil	Clovelly	98-99
yellow over red non-structured subsoil	Griffin	100-101
yellow non-structured subsoil on soft plinthite	Avalon	102-103
weakly structured variegated subsoil with clayskins	Oakleaf	76-77
as for Oakleaf but with signs of wetness	Tukulu	78-79
heavy mottled clay subsoil (bottomland)	Katspruit	108-109
bleached sand on yellow mottled clay (usually wet)	Kroonstad	110-111

Red clays:

deep porous non-structured subsoil	Hutton	90-91
deep weakly structured variegated subsoil with clayskins	Oakleaf	76-77
deep non-structured clay loam on soft plinthite	Bainsvlei	94-95

COASTAL LOWLANDS, RIVER VALLEY AND HINTERLAND SYSTEMS

NGS (Ordinary)

Grey loamy sands:

sandy subsoil with clay tongues into yellow weathering rock	Glenrosa	74-75
soft plinthite on yellow mottled subsoil	Westleigh	70-71
deep weakly structured variegated subsoil with clayskins	Oakleaf	76-77
yellow mottled waterlogged clay subsoil	Katspruit	108-109

Grey sands with a bleached sandy subsoil horizon:

deep grey unconsolidated sand	Fernwood	112-113
sandy subsoil with clay tongues into rock	Cartref	118-119
variegated subsoil with clayskins	Vilafontes	120-121
soft plinthite on yellow mottled clay	Longlands	114-115
yellow mottled clay subsoil (bottomland)	Kroonstad	110-111

Red loams:

deep porous non-structured subsoil	Hutton	90-91
deep weakly structured variegated subsoil with clayskins	Oakleaf	76-77
deep non-structured clay loam on soft plinthite	Bainsvlei	94-95

7. DWYKA TILLITE

MISTBELT SYSTEM

Dark brown fluffy humic loams:

shallow subsoil with clay tongues into rock	Nomanci	40-41
yellow over red non-structured subsoil	Kranskop	50-51
deep yellow non-structured subsoil	Magwa	48-49
deep yellow-brown weakly structured subsoil	Sweetwater	42-43
blocky structured subsoil	Lusiki	44-45

Brown non-structured clays:

yellow-brown subsoil with tongues into weathering rock	Glenrosa	74-75
yellow above red subsoil on rock	Griffin	100-101
yellow subsoil on rock	Clovelly	98-99
yellow-brown subsoil on soft plinthite	Avalon	102-103
yellow mottled waterlogged clay	Pinedene	106-107

Red loams:

deep porous non-structured subsoil	Hutton	90-91
deep weakly structured variegated subsoil with clayskins	Oakleaf	76-77
deep non-structured clay loam on soft plinthite	Bainsvlei	94-95

COASTAL LOWLANDS, RIVER VALLEY AND HINTERLAND SYSTEMS

Grey fine sandy loams:

sandy subsoil with clay tongues into yellow weathering rock	Glenrosa	74-75
soft plinthite on yellow mottled subsoil	Westleigh	70-71
overlying a hard plinthite layer	Dresden	72-73
olive-brown vertically structured clay subsoil	Sterkspruit	86-87

Grey fine sandy loams with a bleached sandy subsoil horizon:

sandy subsoil with clay tongues into rock	Cartref	118-119
soft plinthite on yellow mottled clay	Longlands	114-115
blocky clay subsoil with clayskins	Klapmuts	122-123
vertically structured subsoil with clayskins	Estcourt	124-125
yellow mottled clay subsoil (bottomland)	Kroonstad	110-111

Brown clay:		
yellow-brown subsoil with clay tongues into weathering rock	Glenrosa	74-75
yellow-brown blocky clay subsoil with clayskins	Swartland	80-81
Red clay:		
deep non-structured subsoil	Hutton	90-91
deep non-structured subsoil on soft plinthite	Bainsvlei	94-95
deep non-structured subsoil with signs of wetness	Bloemdal	92-93

DRY LOWVELD SYSTEM

Grey fine sandy loams:		
yellow subsoil with dark clay tongues into weathering rock	Glenrosa	74-75
soft plinthite layer on yellow mottled subsoil	Westleigh	70-71
olive-brown vertically structured clay subsoil	Sterkspruit	86-87
bleached sandy horizon on strong blocky clay subsoil	Estcourt	124-125
yellow mottled waterlogged clay subsoil	Katspruit	108-109

8. PIETERMARITZBURG SHALE

MISTBELT SYSTEM

Brown clays:		
shallow clay on rock	Mispah	68-69
yellow subsoil with clay tongues into weathering rock	Glenrosa	74-75
yellow non-structured subsoil on shale	Clovelly	98-99
yellow above red non-structured subsoil	Griffin	100-101
yellow non-structured subsoil with signs of wetness	Pinedene	106-107

COASTAL LOWLANDS AND RIVER VALLEY SYSTEMS

Dark grey to black blocky clays:		
shallow gravelly clay on shale	Milkwood	58-59
yellow-brown blocky clay subsoil	Bonheim	64-65
yellow heavy mottled waterlogged clay subsoil	Willowbrook	66-67
heavy cracking yellow mottled waterlogged clay subsoil	Rensburg	54-55

HINTERLAND SYSTEM

Grey brown clays:		
shallow stony clay on rock	Mispah	68-69
yellow stony subsoil with clay tongues into weathering rock	Glenrosa	74-75
yellow non-structured subsoil on rock	Clovelly	98-99
yellow non-structured subsoil with signs of wetness	Pinedene	106-107

9. VRYHEID SEDIMENTS (SANDSTONES AND SHALES)

MISTBELT SYSTEM

Dark brown fluffy humic loams:		
shallow non-structured shallow subsoil with clay tongues into rock	Nomanci	40-41
deep non-structured orange/red subsoil	Inanda	46-47
yellow over red non-structured subsoil	Kranskop	50-51
deep non-structured yellow subsoil	Magwa	48-49
deep non-structured variegated subsoil with clayskins	Sweetwater	42-43

Brown clays on shale and grey loams on sandstone:

very shallow shaly soil on rock	Mispah	68-69
shallow shaly subsoil with dark tongues into weathering rock	Glenrosa	74-75
yellow non-structured subsoil	Clovelly	98-99
yellow above red non-structured subsoil	Griffin	100-101
yellow non-structured subsoil on soft plinthite	Avalon	102-103
yellow non-structured subsoil with signs of wetness	Pinedene	106-107

Red clays:

deep porous non-structured subsoil	Hutton	90-91
deep porous non-structured subsoil on soft plinthite	Bainsvlei	94-95
deep porous non-structured subsoil with signs of wetness	Bloemdal	92-93

COASTAL LOWLANDS, RIVER VALLEY AND HINTERLAND SYSTEMS

Grey sands to sandy clay loams:

shallow soil on rock	Mispah	68-69
yellow subsoil with dark tongues into weathering rock	Glenrosa	74-75
shallow blocky clay subsoil	Swartland	80-81
soft plinthite on yellow mottled subsoil	Westleigh	70-71
bleached sandy subsoil on soft plinthite	Longlands	114-115
bleached sand on yellow mottled clay (usually wet)	Kroonstad	110-111
yellow mottled waterlogged clay subsoil	Katspruit	108-109

Dark blocky clays:
(mostly Coastal Lowlands and River Valley)

shallow gravelly clay on rock	Milkwood	58-59
shallow blocky clay subsoil with clay tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil	Bonheim	64-65
yellow heavy mottled waterlogged clay subsoil	Willowbrook	66-67
heavy cracking waterlogged clay subsoil	Rensburg	54-55

DRY LOWVELD SYSTEM

Grey sands to loams:

shallow soil on rock	Mispah	68-69
shallow subsoil with dark tongues into weathering rock	Glenrosa	74-75
bleached sandy subsoil with clay tongues into rock	Cartref	118-119
shallow blocky clay subsoil	Swartland	80-81
olive-brown vertically structured clay subsoil	Sterkspruit	86-87
bleached sandy horizon on brown blocky clay subsoil	Estcourt	124-125
bleached sandy horizon on soft plinthite	Longlands	114-115
bleached sand on yellow mottled clay subsoil (usually wet)	Kroonstad	110-111
yellow mottled waterlogged clay subsoil	Katspruit	108-109

Black blocky clays:

shallow non-cracking clay on shale	Milkwood	58-59
blocky clay subsoil with clay tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil	Bonheim	64-65
blocky clay on yellow mottled clay (bottomland)	Willowbrook	66-67
heavy cracking waterlogged clay subsoil	Rensburg	54-55

10. TARKASTAD SEDIMENTS

DRY LOWVELD AND COASTAL LOWLANDS SYSTEMS

Grey loams:		
very shallow loam on rock	Mispah	68-69
yellow subsoil with dark tongues into weathering rock	Glenrosa	74-75
bleached sandy horizon on blocky clay subsoil	Estcourt	124-125
bleached sandy horizon on soft plinthite	Longlands	114-115
yellow mottled waterlogged clay subsoil	Katspruit	108-109
Dark loams and clays:		
shallow brown blocky clay subsoil with clayskins	Swartland	80-81
black blocky clay subsoil	Milkwood	58-59
olive brown blocky clay subsoil with clayskins	Bonheim	64-65
yellow mottled waterlogged clay subsoil	Willowbrook	66-67

11. CLARENS SANDSTONE

DRY LOWVELD SYSTEM

Grey loamy sands:		
very shallow soil on rock	Mispah	68-69
yellow or red subsoil with dark tongues into weathering rock	Glenrosa	74-75
Red loams:		
deep porous non-structured subsoil	Hutton	90-91

12. DOLERITE - BASALT - DIABASE

MISTBELT SYSTEM

Dark brown fluffy humic loams:		
deep non-structured orange/red subsoil	Inanda	46-47
deep non-structured yellow over red subsoil	Kranskop	50-51
deep non-structured yellow subsoil	Magwa	48-49
deep porous non-structured red subsoil	Hutton	90-91

ALL SYSTEMS EXCEPT MISTBELT AND COASTAL SANDS

Red blocky structured clays:		
deep porous non-cracking clay on weathered rock	Shortlands	88-89
shallow red-brown cracking clay on rock	Arcadia	52-53
Black blocky structured clays:		
shallow cracking clay on rock (upland)	Arcadia	52-53
shallow non-cracking clay with dark tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope)	Bonheim	64-65
blocky clay on yellow mottled clay (bottomland)	Willowbrook	66-67
heavy cracking waterlogged clay subsoil (bottomland)	Rensburg	54-55
Red non-structured clays (Hinterland):		
deep porous subsoil on weathered rock	Hutton	90-91
deep porous subsoil on soft plinthite	Bainsvlei	94-95
deep porous subsoil with signs of wetness	Bloemdal	92-93

13. CRETACEOUS SEDIMENTS

COASTAL LOWLANDS AND DRY LOWVELD SYSTEMS

Black blocky structured clays:		
shallow cracking clay on rock (upland)	Arcadia	52-53
shallow non-cracking clay with dark tongues into weathering rock	Mayo	62-63
yellow-brown blocky clay subsoil (lower slope) with clayskins	Bonheim	64-65
blocky clay on yellow mottled clay (bottomland)	Willowbrook	66-67
heavy cracking waterlogged clay subsoil (bottomland)	Rensburg	54-55
Dark grey loams:		
shallow yellow-brown subsoil with dark clay tongues into weathering rock	Glenrosa	74-75
shallow yellow-brown or black blocky clay subsoil with clayskins	Valsrivier	82-83
yellow mottled waterlogged clay subsoil	Katspruit	108-109

14. RECENT SANDS

COASTAL LOWLANDS SYSTEM

Red sands to sandy loams:		
deep non-structured subsoil	Hutton	90-91
bleached grey sand on red subsoil	Shepstone	126-127
Deep sands (no water table):		
grey sandy subsoil	Fernwood	112-113
light coloured dune sand	Namib	132-133
yellow sandy subsoil	Clovelly	98-99
Grey sands (wet and low-lying areas):		
sandy subsoil with abundant mottling	Fernwood	112-113
sandy subsoil on hard plinthite	Dresden	72-73
bleached sandy subsoil on hard plinthite	Wasbank	116-117
bleached sandy subsoil on yellow mottled clay	Kroonstad	110-111
Dark peat:		
humus-rich topsoil on sand	Champagne	38-39

15. ALLUVIUM

ALL SYSTEMS

Alternating layers of sand and silt due to flood deposition	Dundee	130-131
Deep grey unconsolidated sand	Fernwood	112-113

MISTBELT SYSTEM

Grey topsoils:		
variegated weakly structured subsoil with clayskins	Oakleaf	76-77
yellow mottled waterlogged clay subsoil	Katspruit	108-109
Black peat:		
humus-rich topsoil on waterlogged mottled subsoil	Champagne	38-39

COASTAL LOWLANDS, HINTERLAND AND DRY LOWVELD SYSTEMS

Red soils:		
deep porous non-structured	Hutton	90-91
variegated weakly structured subsoil with clayskins	Oakleaf	76-77
blocky structured clay subsoil	Valsrivier	82-83
deep blocky structured clay	Shortlands	88-89
Grey soils with yellow-brown subsoils:		
deep sandy subsoil	Clovelly	98-99
variegated weakly structured subsoil with clayskins	Oakleaf	76-77
blocky structured clay subsoil	Valsrivier	82-83
Grey soils:		
yellow mottled waterlogged clay subsoil	Katspruit	108-109
Grey soils with a bleached sandy horizon:		
on soft plinthite	Longlands	114-115
on brown blocky clay subsoil	Estcourt	124-125
on yellow mottled clay	Kroonstad	110-111
Black blocky structured clays:		
yellow-brown blocky clay subsoil	Bonheim	64-65
blocky clay on soft plinthite	Tambankulu	60-61
alternating layers of sand and clay in subsoil	Inhoek	56-57
non-cracking yellow mottled clay subsoil (bottomland)	Willowbrook	66-67
cracking yellow mottled clay subsoil (bottomland)	Rensburg	54-55
Black peat:		
humus-rich topsoil on yellow mottled waterlogged clay	Champagne	38-39

HUMID LOWVELD SYSTEM

Red loams:		
deep non-structured subsoil	Hutton	90-91
variegated weakly structured subsoil with clayskins	Oakleaf	76-77
Black clays:		
blocky structured on yellow mottled clay (bottomland)	Willowbrook	66-67
cracking yellow mottled clay subsoil (bottomland)	Rensburg	54-55
Grey soil:		
bleached sand on wet mottled clay	Kroonstad	110-111
yellow mottled waterlogged clay subsoil	Katspruit	108-109

16. TRANSPORTED MATERIAL

ALL SYSTEMS

man-made soil profile (variable)	Witbank	134-135

Depth must be greater than 500 mm if overlying a classifiable buried soil.

PROCEDURE

If you are unable to identify the soil parent material and do not possess a soil parent material map then the binomial system of classification should be used to obtain the soil form and series as described on the following pages.

A summary of the procedure follows:

Step 1: Expose a profile of the soil to be identified.

Step 2: Mark off and identify the diagnostic soil horizons (see page 30).

Step 3: Name the soil form by consulting the soil form key (see page 34).

Step 4: Use the page number shown in brackets next to the soil form to locate the colour plate of the identified form.

Step 5: Select the appropriate soil series or family from the table below the colour plate using criteria such as texture, grade of sand, colour, or soil system. (In some instances it will be necessary to have the base status of the soil confirmed by laboratory analysis before the correct series can be chosen.)

Example

Use fields 101 and 102 on the farm XYZ shown on page 10.

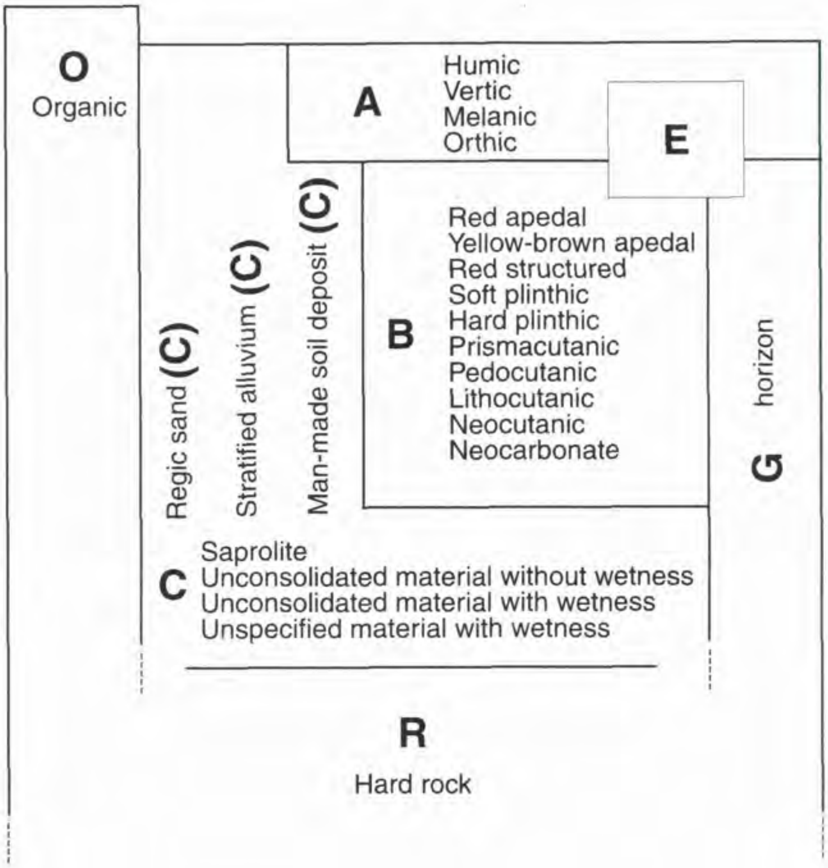
Field 101	Step 1:	Shallow dark brown clay loam topsoil (A horizon) over a red blocky subsoil (B horizon).
	Step 2:	A horizon diagnosed as orthic A. B horizon diagnosed as red structured B.
	Step 3:	Shortlands form (from page 34).
	Steps 4 & 5:	Shortlands series (clay, from pages 88-89).
Field 102	Step 1:	Black cracking clay A horizon (less than 500 mm deep) on well drained weathering rock. No evidence of a B horizon.
	Step 2:	A horizon diagnosed as vertic A.
	Step 3:	Arcadia form (from page 34).
	Steps 4 & 5:	Rydalvale series (black, from pages 52-53).

Step 1 : Expose a soil profile in a pit or on a road embankment

The profile should be at least 1,2 metres deep or to the depth of a shallower impervious layer. Discount any recent material occurring on the surface of the topsoil. (For further information regarding pit siting, soil surveys and mapping, see Appendix 5, page 163.)

Step 2 : Mark off the boundary between the topsoil and subsoil horizons and any other distinct horizons

- Record the depths of each of the horizons.
- Determine the colour, structure and texture of the topsoil (A horizon). In the case of heavy blocky clays note whether there is any sign of cracking, self-mulching or slickensides.
- Note the structure and colours of the subsoil (B horizon) and establish whether or not they are uniform.
- Determine whether there are signs of periodic waterlogging as indicated by grey or greyish-brown colours, yellowish-red mottling, a bleached sandy layer (E horizon), a layer of ironstone concretions (plinthite) or a firm gley at depth (G horizon).
- A guide to describing properties such as colour, texture and structure, is given in Appendix 3 (page 156).
- Select from the list of five diagnostic topsoil and 20 subsoil horizons of the bionomial system that regularly occur in the sugar industry, those that match your profile description. The names of these horizons and their relative positions in the soil profile are given in the diagram on page 30, while a brief description of each topsoil and subsoil follows. A thorough understanding of these descriptions is required to ensure that the correct diagnostic horizon is selected. This can be checked by comparing your description with the specifications listed in the descriptions. In the case of subsoil horizons, these should occur within 1 500 mm of the surface.



Diagnostic horizons and materials

DESCRIPTION OF DIAGNOSTIC HORIZONS

TOPSOIL HORIZONS

1. ORGANIC O

- rich in organic matter, with at least 10% organic carbon (or more than 18 to 20% organic matter) throughout a depth of at least 200 mm
- saturated with water for long periods in most years, unless drained
- normally black or dark brown in colour
- partly decomposed organic material often present at the surface and sometimes throughout this horizon
- also known as peat, and rare in South Africa

2. HUMIC A

- rich in humified organic matter – at least 1,8% organic carbon (or more than 3,5% organic matter)
- highly leached and moderately to strongly acid
- dark in colour, especially when moist; brown and powdery when dry
- friable consistency and lacks blocky structure
- usually more than 450 mm deep but thin horizons do occur
- found in well drained upland sites, in humid cool mistbelt conditions

3. VERTIC A

- strongly developed blocky structure with shiny ped faces and wide vertical cracks when dry
- high clay content; mostly clays which shrink when dry and swell when wet
- slickensides or polished surfaces due to soil movement occur regularly – often near the transition to an underlying layer
- high plasticity index (does not easily liquefy) but is very sticky when wet
- usually black in colour but may also be red, yellow-brown or grey
- self-mulching is common
- usually developed from dolerite, basalt, Swaziland basic rocks or Tugela schist

4. **MELANIC A**

- colour is dark – usually black
- non-swelling clays predominate but structure is moderate to strong blocky
- lacks slickensides that are diagnostic of vertic horizons
- plasticity index is lower than for vertic horizons
- base saturation is high
- organic matter is less than required for an organic O horizon but usually low in the cane belt

5. **ORTHIC A**

- surface horizon does not qualify as an organic, humic, vertic or melanic topsoil, although it can be darkened by organic matter
- varies widely in colour, texture, structure and base status but is usually low in organic matter
- usually less than 400 mm deep

SUBSOIL HORIZONS

Hard material or weathering rock

This is rock-like in appearance even when the material is weathered. It is very slowly permeable or impermeable.

1. **HARD PLINTHIC B**

- consists of an indurated hard layer of accumulated iron and manganese oxides which cannot be cut with a spade when wet
- often also known as *ouklip, ironpan, laterite or ferricrete*
- plinthite formation is part of a soil forming process – not the weathering of a parent material; however, many relic ironpans occur and it is difficult to distinguish between the two
- occurs beneath an orthic A, an E horizon or a yellow-brown apedal B

2. **HARD ROCK**

- is a continuously hard layer of rock that cannot be cut with a spade, even when wet
- occurs beneath a diagnostic orthic or melanic A horizon

3. **LITHOCUTANIC B**

- underlies a diagnostic topsoil horizon, either directly or via a stone-line, or an E horizon and merges into underlying weathering rock
- tongues or cones of soil penetrate into the weathering rock resulting in a highly variegated, laterally non-continuous horizon
- clayskins of iron or manganese oxide or organic matter are very prominent on the surface of the weathering rock or saprolite

4. **SAPROLITE**

- an horizon of weathering rock, with a general organisation in respect of colour, structure and consistence, which still has affinities with the parent rock
- grades into relatively unweathered and, eventually, hard rock
- diagnostic saprolite is typically found in upland, often convex, topography while non-diagnostic saprolite is a common feature of many soils

Structured subsoils

The structure of the following three horizons is moderate to strong but the size of the peds is variable.

5. **RED STRUCTURED B**

- mainly a uniform red colour, although red cutans and colour variation due to faunal activity may be present
- blocky structure is moderate to strong due to the presence of shrink/swell clays (2:1 clay minerals)
- clay content is usually above 35%
- underlies an orthic A horizon which is also often reddish with a blocky structure – the transition is gradual

6. **PEDOCUTANIC B**

- underlies a diagnostic topsoil horizon or an E horizon
- moderately or strongly developed blocky structure
- prominent clayskins on most ped surfaces result in non-uniform or variegated colours
- transition from A to B horizon is abrupt with red pedocutanic B horizons

7. PRISMACUTANIC B

- structure must be prismatic or columnar (usually coarse)
- very abrupt transition of texture and structure with the overlying orthic A or E horizon
- if the clay content of the material above is less than 20%, then the clay content below must be at least twice as high
- if the above material has more than 20% clay, then the material below must show an absolute increase of at least 20% clay
- lacks evidence of wetness (light grey colours) or, if it has signs of wetness, then the clayskins are a uniform dark colour
- exhibits colour contrast between the clayskins and the ped interiors

Uniformly coloured subsoils

These horizons are freely drained and are old and mature.

8. RED APEDAL B

- mainly uniform red colours – only colour variations allowed are due to faunal activity
- lacks visible structure but has well developed porous micro-aggregates (individual soil particles are coated with ferric iron oxide)
- texture can vary enormously but clay minerals are dominated by mature non-swelling 1:1 types
- many red apedal B horizons have accumulated clay and fine material by way of illuviation
- does not effervesce when treated with 10% hydrochloric acid
- does not have alluvial or aeolian stratifications
- underlies an orthic or humic topsoil, an E horizon or a yellow-brown apedal B horizon

9. YELLOW-BROWN APEDAL B

- mainly uniform yellow and yellow-brown colours although mottles and concretions are permitted if insufficient to qualify for a plinthic horizon
- does not have grey E horizon colours in the dry state
- a colour which is 'yellow' in the dry state and which qualifies as 'red' in the moist state, is diagnostic red and not diagnostic yellow-brown
- structure as defined for red apedal B horizons
- does not effervesce when treated with 10% hydrochloric acid
- does not have alluvial or aeolian stratifications
- underlies an orthic or a humic topsoil or an E horizon

10. NEOCARBONATE B

- directly underlies a topsoil or an E horizon
- effervesces visibly when treated with cold 10% hydrochloric acid
- develops anywhere in the landscape in arid and semi-arid regions and on lower slopes in more humid climates, on parent materials rich in calcium and or magnesium
- resembles red apedal, yellow-brown apedal, neocutanic, stratified alluvium, regic sand or man-made horizons (NB. in the latter four horizons the colour may not be uniform)

Non-uniformly coloured subsoil (clayskins)

These horizons comprise relatively young, free draining material.

11. NEOCUTANIC B

- underlies a diagnostic topsoil or an E horizon
- has weakly developed structure, variegated colours or clayskins
- often occurs on alluvial or colluvial deposits, on termitaria as well as in other situations
- must lack signs of stratification in materials which were formerly stratified alluvium
- occasionally is a uniform dark brown colour which does not qualify for either red apedal or yellow-brown apedal
- does not effervesce when treated with 10% hydrochloric acid

12. UNCONSOLIDATED MATERIAL WITHOUT SIGNS OF WETNESS

- underlies a diagnostic pedocutanic B horizon
- usually occurs in footslope positions
- may be any combination of organic matter, clay, silt, sand and coarse fragments not resembling saprolite
- without mottles and lacks the grey, low chroma colours that are evidence of wetness

Restricted drainage

Poorly drained subsoil horizons are either found in valley bottoms and footslopes or associated with springs, seepage planes and relatively impermeable lower horizons.

13. E HORIZON

- directly underlies an orthic topsoil horizon except where mixing or topsoil erosion has occurred
- colour is light grey in the dry state but is sometimes yellowish or pinkish when moist – it may contain mottles and streaks due to periodic waterlogging
- usually bleached and both paler in colour and lighter in texture than the topsoil above
- loose and friable when moist but can be hard and brittle when dry or fluid (running sands) when saturated
- has undergone marked removal (eluviation) of colloidal matter (iron oxides, silicate clay and organic matter)
- where a light grey sandy topsoil, deeper than 350 mm, cannot easily be distinguished from similar material below, then an 'E' horizon is definitely present
- usually overlies impervious material but can extend to considerable depth
- in deep E horizons lamellae are common but cross bedding is not allowed

14. G HORIZON

- underlies an organic, vertic, melanic, orthic or an 'E' horizon
- saturated with water for long periods of time unless drained
- dominated by the reduction of iron oxide or gleyed grey matrix colours, often with blue or green tints, with or without mottling
- accumulation of clay or organic matter (illuviation) has usually taken place
- lacks both saprolitic and plinthic character
- any type or degree of structure except prismatic or columnar with uniformly dark coloured ped faces

15. SOFT PLINTHIC B

- accumulated localised iron and manganese oxides, under conditions of a fluctuating water table, to give many distinct reddish-brown, yellowish-brown and/or black mottles or concretions – more than 10% by volume and often known as 'ngubane' in KwaZulu-Natal
- has grey colours caused by gleying, either in the horizon or immediately below it
- can be cut with a spade when wet, even though individual concretions may be hard

16. UNSPECIFIED MATERIAL WITH SIGNS OF WETNESS

- underlies red apedal, yellow-brown apedal, neocutanic or neocarbonate B horizons
- can vary from unconsolidated soil material to partly weathered rock
- has grey, low chroma matrix colours, due to reduction and iron loss, that have been caused by wetness
- if present, mottles may be yellowish-brown, olive-brown, red or black

17. UNCONSOLIDATED MATERIAL WITH SIGNS OF WETNESS

- similar to above but underlies a pedocutanic B horizon and does not qualify as either hard rock or saprolite.

Transported material

All these horizons have been transported by water, gravity, wind or man.

18. STRATIFIED ALLUVIUM

- unconsolidated and contains stratifications caused by alluvial or colluvial deposition
- underlies an orthic or melanic A horizon, or occurs at the surface
- does not qualify as a diagnostic regic sand

19. REGIC SAND

- underlies an orthic A horizon or occurs at the surface
- a recent deposit, usually aeolian, which shows little development other than a darkening of the topsoil by organic matter
- has little silt or clay, virtually no structure but cross bedding may be present
- can be any colour although light grey colours are common

20. MAN-MADE SOIL DEPOSIT

- is a man-made deposit of soil material, with or without rock fragments or man-made materials
- depth must be greater than 500 mm if overlying a classifiable buried soil

Step 3 : Name the soil form by consulting the soil form key

By determining the presence or absence, sequence and depth of the diagnostic horizons the appropriate soil form can be determined by referring to the following soil form key. Form names are arranged according to the defined topsoil and subsoil horizons. For example, a soil with an orthic A over a red apedal B horizon will be classified as the **Hutton form**. Another soil profile with the same topsoil but a red structured B subsoil will be classified as the **Shortlands form**.

KEY TO THE SOIL FORMS

(page reference in brackets)

SUBSOIL HORIZONS	TOPSOIL HORIZONS				
	Organic	Humic	Vertic	Melanic	Orthic
unspecified	Champagne (38)		Arcadia (52)	Inhoek (56)	
hard rock				Milkwood (58)	Mispah (68)
soft plinthic B				Tambankulu (60)	Westleigh (70)
hard plinthic B					Dresden (72)
lithocutanic B		Nomanci (40)		Mayo (62)	Glenrosa (74)
neocutanic B		Sweetwater (42)			Oakleaf (76)
neocutanic B / unspecified wet					Tukulu (78)
pedocutanic B / saprolite		Lusiki (44)		Bonheim (64)	Swartland (80)
pedocutanic B / unconsolidated					Valsrivier (82)
pedocutanic B / unconsolidated wet					Sepane (84)
prismacutanic B / unspecified					Sterkspruit (86)
red structured B					Shortlands (88)
red apedal B / unspecified		Inanda (46)			Hutton (90)
red apedal B / unspecified wet					Bloemdal (92)
red apedal B / soft plinthic B					Bainsvlei (94)
neocarbonate B / unspecified					Augrabies (96)
yellow-brown apedal B		Magwa (48)			Clovelly (98)
yellow-brown apedal / red apedal B		Kranskop (50)			Griffin (100)
yellow-brown apedal / soft plinthic B					Avalon (102)
yellow-brown apedal / hard plinthic B					Glencoe (104)
yellow-brown apedal B / unspecified wet					Pinedene (106)
G horizon			Rensburg (54)	Willowbrook (66)	Katspruit (108)
E horizon / G horizon					Kroonstad (110)
E horizon / unspecified					Fernwood (112)
E horizon / soft plinthic B					Longlands (114)
E horizon / hard plinthic B					Wasbank (116)
E horizon / lithocutanic B					Cartref (118)
E horizon / neocutanic B					Vilafontes (120)
E horizon / pedocutanic B					Klapmuts (122)
E horizon / prismacutanic B					Estcourt (124)
E horizon / red apedal B					Shepstone (126)
E horizon / yellow-brown apedal B					Constantia (128)
stratified alluvium					Dundee (130)
regic sand					Namib (132)
man-made					Witbank (134)

Step 4 : Use page number given in brackets next to soil form to locate colour plate of form

The 49 soil forms contained in this bulletin have been arranged into groups based on similar topsoil or subsoil horizons. Where applicable, forms have been arranged in relation to their position in the landscape, from the highest (crest) to the lowest (bottomland) level. In practice, the soil forms in any toposequence will depend on the soil system and nature of the underlying parent material.

Step 5 : Identify the soil series or family

The final step is to identify the appropriate soil series or family from the table below the colour plate. Various criteria such as texture, grade of sand, colour, base status and soil system, may be used. In most cases these properties can be determined in the field. The soil system in which your farm is situated (refer to soil system maps), is generally a good indicator of base status:

e.g.	Mistbelt and Hinterland Systems	low base status
	Coastal Lowlands and Coastal Sands Systems	medium base status
	River Valley and Dry/Humid Lowveld Systems	high base status.

Where textural and chemical analyses of the diagnostic horizon have been carried out, the soil series or family can be identified more accurately from the two tables facing the soil form colour plate. The correct soil series will be the one with a clay content closest to that of the diagnostic horizon. In the case of the Hutton, Bainsvlei, Clovelly, Griffin, Avalon, Glenrosa and Pinedene forms, the series is identified from the clay content and base status of the B horizon. Some of the following criteria are used to distinguish soil forms at the family level: A horizon bleached or non-bleached; B horizon red or non-red, luvic or non-luvic.

MAIN SOIL GROUPS

Pages

3.2 Moderately drained red soils

• BAINSVLEI	orthic A / red apedal B / soft plinthic B	94-95
• BLOEMDAL	orthic A / red apedal B / unspecified material with wetness	92-93
• SHEPSTONE	orthic A / E / red apedal B	126-127

4. YELLOW AND YELLOW-BROWN SOILS (only about 1 or 2% of the sugar industry)

4.1 Well drained yellow and yellow/brown soils

• CLOVELLY	orthic A / yellow-brown apedal B	98-99
• GRIFFIN	orthic A / yellow-brown apedal B / red apedal B	100-101

4.2 Moderately and pooly drained yellow and yellow/brown soils; more commonly found on lower slopes and southern aspects

• AVALON	orthic A / yellow-brown apedal B / soft plinthic B	102-103
• GLENCOE	orthic A / yellow-brown apedal B / hard plinthic B	104-105
• CONSTANTIA	orthic A / E / yellow-brown apedal B	128-129
• PINEDENE	orthic A / yellow-brown apedal B / unspecified material with wetness	106-107
• SWARTLAND	orthic A / pedocutanic B / saprolite (see also 3.1, 5.2)	80-81
• VALSRIVIER	orthic A / pedocutanic B / unconsolidated material without wetness	82-83

5. GREY SOILS (about 60% of the sugar industry – coastal, midland and lowveld areas)

5.1 Grey crest to midslope soils (20 to 25%)

• CARTREF	orthic A / E / lithocutanic B (sometimes also on lower slopes)	118-119
• GLENROSA	orthic A / lithocutanic B	74-75
• MISPAH	orthic A / hard rock	68-69
• DRESDEN	orthic A / hard plinthic B (sometimes also on lower slopes)	72-73
• OAKLEAF	orthic A / neocutanic B / unspecified (see also section 5.2, 5.4, 3.1)	76-77
• WITBANK	orthic A / man-made soil deposit	134-135

5.2 Grey lower slope soils (20 to 25%)

• ESTCOURT	orthic A / E / prismacutanic B	124-125
• STERKSPRUIT	orthic A / prismacutanic B / unspecified	86-87
• KLAPMUTS	orthic A / E / pedocutanic B	122-123
• VILAFONTES	orthic A / E / neocutanic B	120-121
• LONGLANDS	orthic A / E / soft plinthic B	114-115
• WASBANK	orthic A / E / hard plinthic B	116-117
• OAKLEAF	orthic A / neocutanic B / unspecified (see also 3.1, 5.1, 5.4)	76-77
• TUKULU	orthic A / neocutanic B / unspecified material with wetness	78-79
• SWARTLAND	orthic A / pedocutanic B / saprolite (can also be red, yellow or black)	80-81
• VALSRIVIER	orthic A / pedocutanic B / unconsolidated material without wetness	82-83
• SEPANE	orthic A / pedocutanic B / unconsolidated material with wetness (also red, yellow or black)	84-85
• WESTLEIGH	orthic A / soft plinthic B (sometimes also found in upland situations)	70-71

5.3 Grey poorly drained, bottomland soils (about 5%)

• KATSPRUIT	orthic A / G	108-109
• KROONSTAD	orthic A / E / G	110-111

5.4 Deep, well drained, light textured soils (about 5 to 10%)

• DUNDEE	orthic A / stratified alluvium	130-131
• FERNWOOD	orthic A / E / unspecified	112-113
• NAMIB	orthic A / regic sand	132-133
• HUTTON	orthic A / red apedal B (red Recent Sands) (see also 3.1)	90-91
• OAKLEAF (red)	orthic A / neocutanic B / unspecified (see also 3.1, 5.1, 5.2)	76-77

COLOUR PLATES

SELECTED PROPERTIES OF CHAMPAGNE FORM SOIL SERIES

Soil series	*Physical					
	Clay % O horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Mposa	Less than 20	140 to 180	Medium to poor	Poor to moderate	Low	Absent
Stratford	More than 20	140 to 180	Medium to poor	Poor to moderate	Low	Absent
Champagne	Less than 20	140 to 180	Medium to poor	Poor to moderate	Low	Absent
Ivanhoe	More than 20	140 to 180	Medium to poor	Poor to moderate	Low	Absent

Soil series	*Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Mposa	Below 4,0	Low to moderate	Moderate to high	Moderate	Very high	Very high	Low	Moderate	Low
Stratford	Below 4,0	Low to moderate	Moderate to high	Moderate	Very high	Very high	Low	Moderate	Low
Champagne	Above 4,0	Low to moderate	Moderate	Moderate	Very high	Very high	Low	Moderate	Low
Ivanhoe	Above 4,0	Low to moderate	Moderate	Moderate	Very high	Very high	Low	Moderate	Low

*For a further explanation of the physical and chemical properties of the various soil forms, see Appendices 3 and 4, pages 156 and 160 respectively.

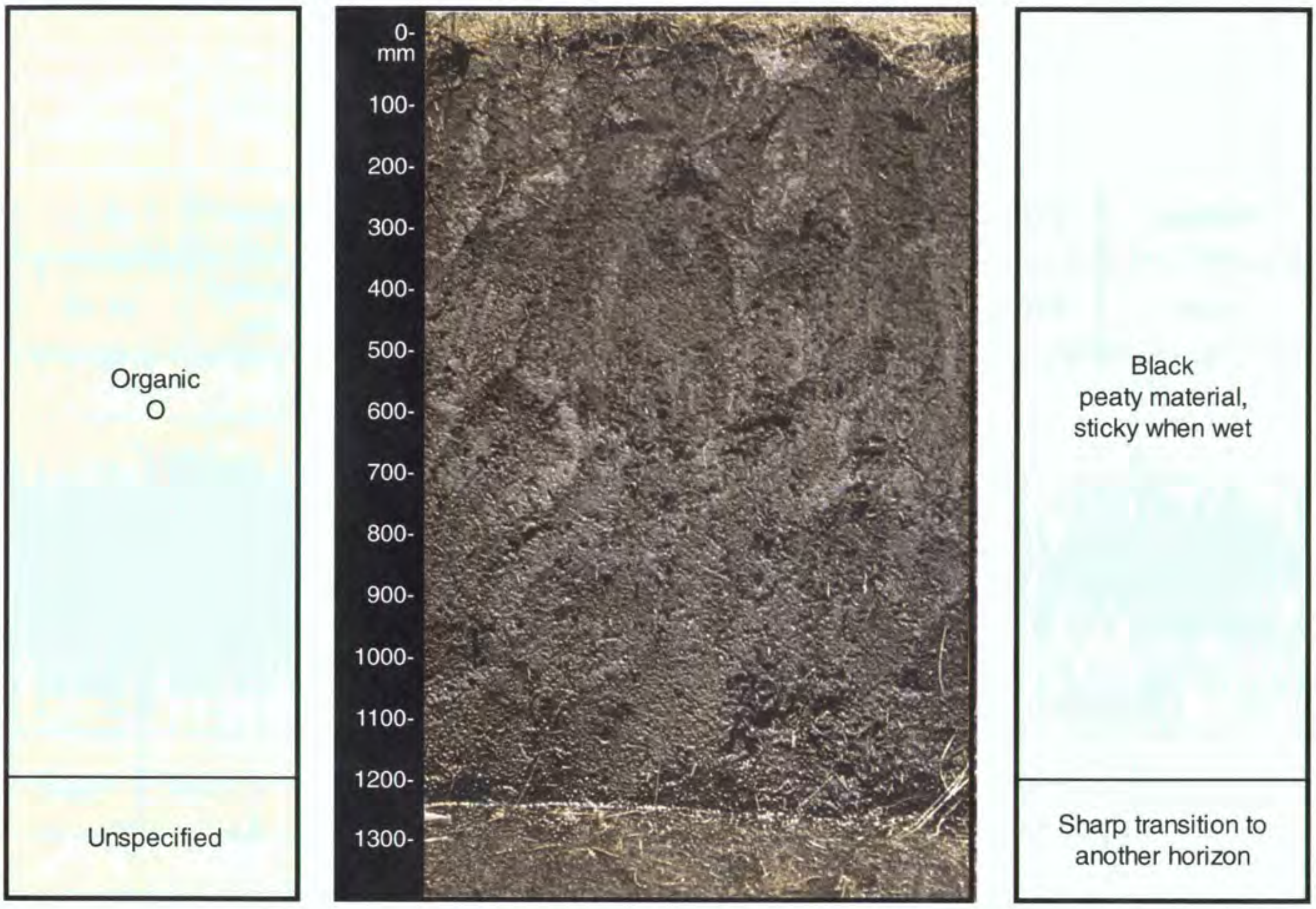
Correlation FAO

Dystric and Eutric Histosols

Correlation USDA

Histosols

Champagne Form - Ch*



*Standard abbreviation

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil (clay %)	Soil pH*	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Mposa	Less than 20	Below 4	600 to 1 500
Coastal Lowlands	Alluvium	Stratford	More than 20		600 to 1 200
Mistbelt	Alluvium	Champagne	Less than 20	Above 4	600 to 1 200
		Ivanhoe	More than 20		

*measured in IN KCl

FEATURES TO NOTE

- extent : found mainly in the Mposa flood plain and occupies an area of less than 500 hectares
- water table : true wetland soils found in vleis and old swamp land; ideally should not be cultivated
- nutrient status : large quantities of soil nitrogen are available so applied nitrogen should be markedly less than average; agricultural limestone may be required and potassium and zinc are often low, so soil sampling is essential and leaf analysis a useful guide
- burning : when dry, peat can ignite by spontaneous combustion and burn for months; flooding the area or isolating the fire by ploughing are the only ways to extinguish burning peat
- general : the organic horizon generally overlies gley, sandy alluvium, or may overlie solid rock or saprolite

SELECTED PROPERTIES OF NOMANCI FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Nomanci	Less than 35	100 to 140	Good	Good	Moderate	cr, co
Lusiki	More than 35	140 to 180	Good	Good	Moderate to low	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Nomanci	4,5 to 5,5	Very low	Moderate to high	Moderate	High	High	Low	Low	Absent
Lusiki	5,0 to 5,5	Low	Moderate	High	Very high	Very high	Low	Low	Absent

Correlation FAO

Humic (strongly) Cambisols
Humic Acrisols

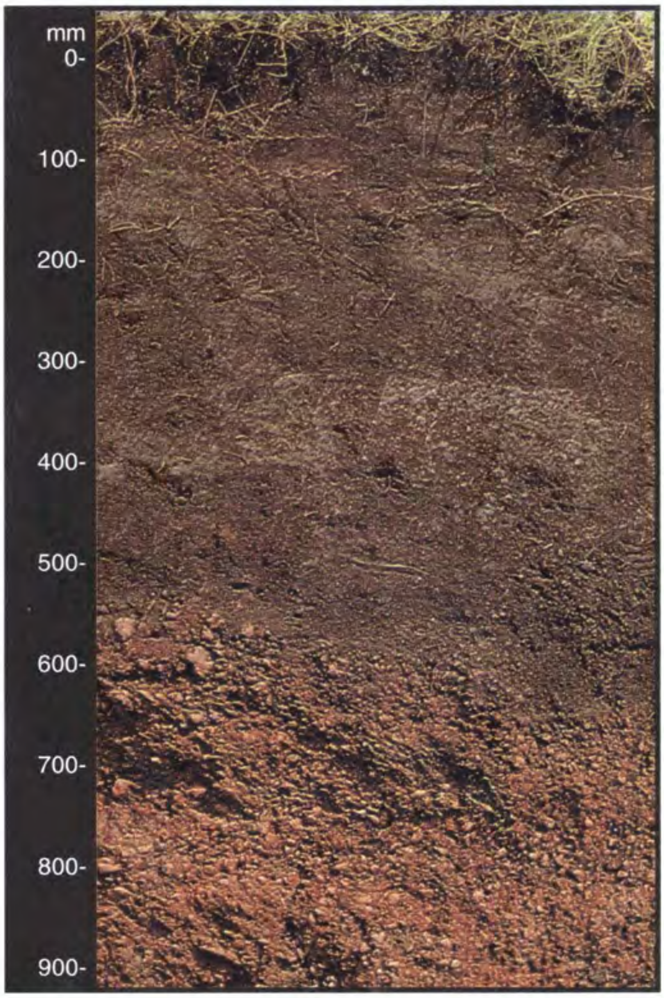
Correlation USDA

Inceptisols

Nomanci Form - No

Humic A

Lithocutanic B



Thick dark brown powdery humic clay loam to clay

Clay tongues into weathering rock

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone Vryheid sediments	Nomanci	Clay loam	Less than 700
	Dwyka tillite Pietermaritzburg shales	Lusiki	Clay	

FEATURES TO NOTE

- physical properties : good
- lime, phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils
- NB : families with thin humic A horizons overlying either soft or hard rock can occur

SELECTED PROPERTIES OF SWEETWATER FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Glenwood	35 to 55	100 to 140	Good	Good	Low	cr, co
Winshaw	35 to 55	100 to 140	Good	Good	Low	cr, co
Copling	35 to 55	100 to 140	Good	Good	Low	cr, co
Fielden	35 to 55	100 to 140	Good	Good	Low	cr, co

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Glenwood	4,5 to 5,5	Low	Moderate	Moderate to high	High	High	Low	Low	Absent
Winshaw	4,5 to 5,5	Low	Moderate	Moderate to high	High	High	Low	Low	Absent
Copling	4,5 to 5,5	Low	Moderate	Moderate to high	High	High	Low	Low	Absent
Fielden	4,5 to 5,5	Low	Moderate	Moderate to high	High	High	Low	Low	Absent

NF - new form in this bulletin

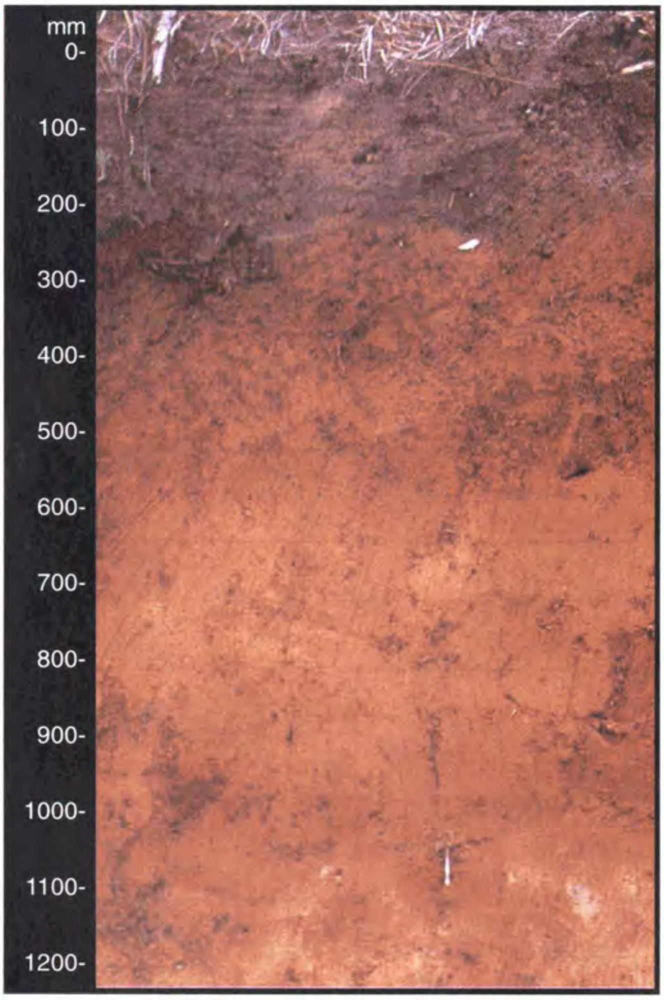
Correlation FAO

Humic Ferralsols

Correlation USDA

Inceptisols
Oxisols

Sweetwater Form - Sr



Humic A	Dark brown powdery humic sandy loam to clay loam
Neocutanic B1	Weakly structured yellow-brown or red clay loam to clay
Neocutanic B2	Porous friable yellow-brown or red weakly structured clay loam
	Non-diagnostic

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone Dwyka tillite Vryheid sediments Dolerite	Glenwood	Shallow topsoil over non-red luvic subsoil	More than 1 200
		Winshaw	Shallow topsoil over red luvic subsoil	
		Copling	Thick topsoil over non-red luvic subsoil	
		Fielden	Thick topsoil over red luvic subsoil	

FEATURES TO NOTE

- physical properties : good
- lime, phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils
- other families : four other families with non-luvic subsoils also occur in this form

SELECTED PROPERTIES OF LUSIKI FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Hopewell	35 to 55	100 to 140	Good	Good	Low	cr, co
Argyll	35 to 55	100 to 140	Good	Good	Low	cr, co
Clifton	35 to 55	100 to 140	Good	Good	Low	cr, co
Coleraine	35 to 55	100 to 140	Good	Good	Low	cr, co

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Hopewell	4,5 to 5,5	Low	Moderate	Moderate	High	Moderate to high	Moderate to low	Low	Absent
Argyll	4,5 to 5,5	Low	Moderate	Moderate	High	Moderate to high	Moderate to low	Low	Absent
Clifton	5,0 to 5,5	Low	Moderate	Moderate to high	High	High to very high	Low	Very low	Absent
Coleraine	5,0 to 5,5	Low	Moderate	Moderate to high	High	High to very high	Low	Very low	Absent

NF - new form in this bulletin

Correlation FAO

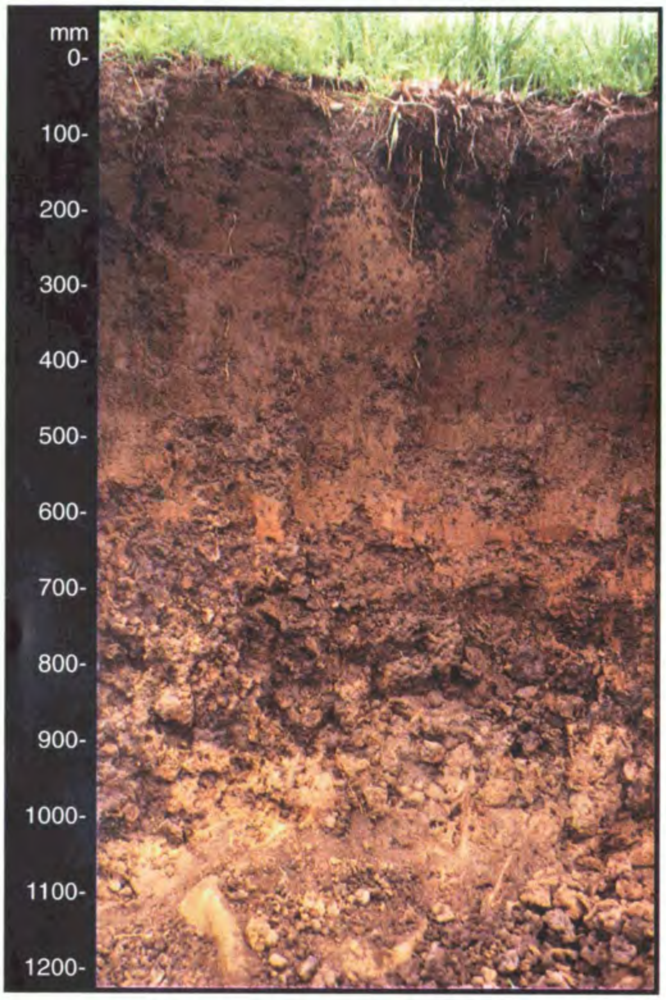
Humic Luvisols

Correlation USDA

Oxisols

Lusiki Form - Lu

Humic A	Dark brown powdery humic sandy clay loam to clay
Pedocutanic B	Yellow-brown or red blocky clay subsoil



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Typical soil families	Main features	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone Dolerite Pietermaritzburg shales Vryheid sediments	Hopewell	Shallow topsoil over medium blocky red clay	1 200
		Argyll	Shallow topsoil over medium blocky non-red clay	
		Clifton	Thick topsoil over medium blocky red clay	
		Coleraine	Thick topsoil over medium blocky non-red clay	

FEATURES TO NOTE

- physical properties : good
- lime, phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils
- other families : four other families with fine angular structured subsoils also occur in this form

SELECTED PROPERTIES OF INANDA FORM SOIL SERIES

Soil series	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Fountainhill	15 to 35	100 to 140	Good	Good	Low to moderate	cr, co
Inanda	35 to 55	140 to 180	Good	Good	Low	cr, co
Sprinz	More than 55	More than 180	Medium to good	Good	Very low	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Fountainhill	4,5 to 5,5	Very low	Moderate to high	Moderate	High	High	Low	Low	Absent
Inanda	5,0 to 5,5	Low	Moderate	High	High	Very high	Low	Low	Absent
Sprinz	5,0 to 5,5	Low	Moderate to low	Very high	Very high	Very high	Low	Low	Absent

Correlation FAO

Humic Ferralsols

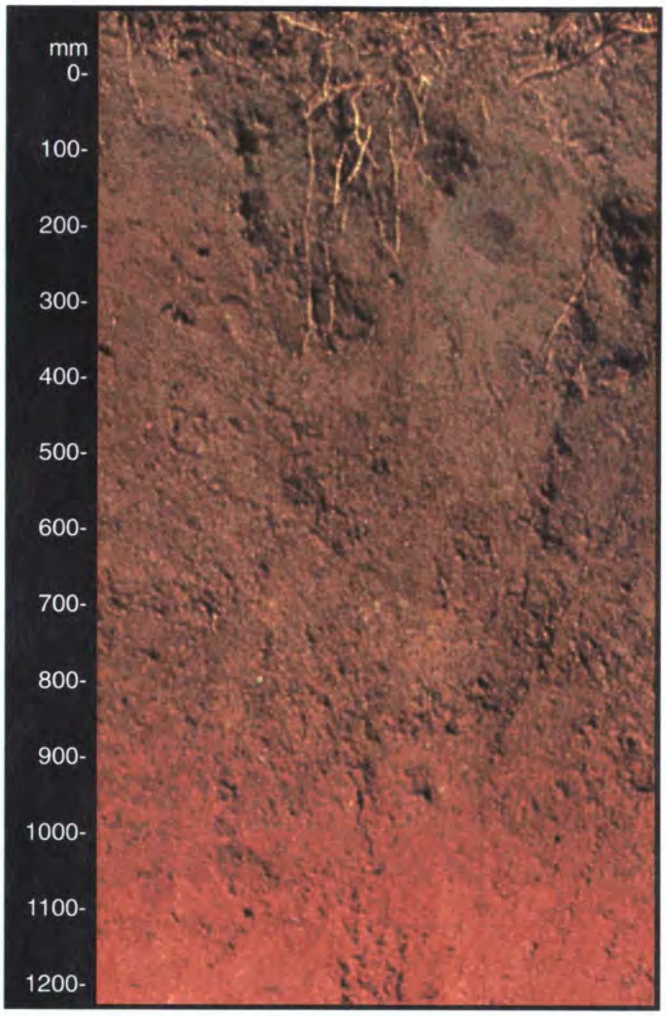
Correlation USDA

Oxisols

Inanda Form - Ia

Humic
A

Red apedal
B



Thick dark brown powdery humic sandy clay loam to clay

Dark red porous friable sandy clay loam to non-structured clay

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone Vryheid sediments Dwyka tillite	Fountainhill	Sandy clay loam	More than 1 000
		Inanda	Clay loam	
	Dolerite	Sprinz	Clay	

FEATURES TO NOTE

- physical properties : good and usually very deep
- lime and gypsum : commonly required to correct aluminium toxicity and deficiencies of calcium and magnesium
- phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- silicon : good responses have been obtained to calcium silicate slag
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils
- other families : soils which were previously known as 'humic phase' Huttons are now accommodated in the family with thin humic A horizons

SELECTED PROPERTIES OF MAGWA FORM SOIL SERIES

Soil series	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Milford	15 to 35	100 to 140	Good	Good	Low to moderate	cr, co
Magwa	35 to 55	140 to 180	Good	Good	Low	cr, co
Frazer	More than 55	More than 180	Medium to good	Good	Very low	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Milford	4,5 to 5,5	Very low	Moderate to high	Moderate	High	High	Low	Low	Absent
Magwa	4,5 to 5,5	Low	Moderate	High	High	High	Low	Low	Absent
Frazer	4,5 to 5,5	Low	Moderate to low	Very high	Very high	High	Low	Low	Absent

Correlation FAO

Humic (strongly) Cambisols

Correlation USDA

Oxisols

Magwa Form - Ma

Humic A	Thick dark brown powdery humic sandy clay loam to clay
Yellow apedal B	Yellow-brown porous friable clay loam to non-structured clay

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone	Milford	Sandy clay loam	700 to 1 200
		Magwa	Clay loam	
		Frazer	Clay	

FEATURES TO NOTE

- physical properties : good
- lime and gypsum : commonly required to correct aluminium toxicity and deficiencies of calcium and magnesium
- phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- silicon : good responses have been obtained to calcium silicate slag
- filtercake and poultry manure : recommended where soil P levels are deficient
- other families : soils previously known as 'humic phase' Clovellys are now accommodated in a family with thin humic A horizons

SELECTED PROPERTIES OF KRANSKOP FORM SOIL SERIES

Soil series	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Kipipiri	15 to 35	100-140	Good	Good	Low to moderate	cr, co
Kranskop	35 to 55	140-180	Good	Good	Low	cr, co
Umbumbulu	More than 55	More than 180	Medium to good	Moderate	Low	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Kipipiri	4,5 to 5,5	Very low	Moderate to high	Moderate	High	High	Low	Low	Absent
Kranskop	5,0 to 5,5	Low	Moderate	High	High	High	Low	Low	Absent
Umbumbulu	5,0 to 5,5	Low	Moderate to low	Very high	Very high	High	Low	Low	Absent

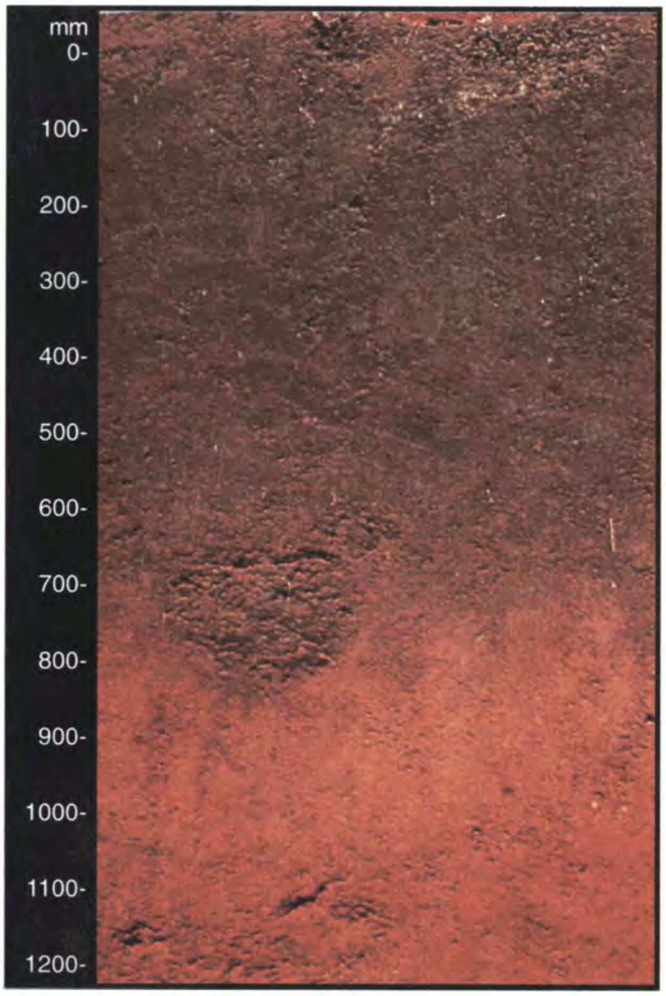
Correlation FAO

Humic Acrisols

Correlation USDA

Oxisols

Kranskop Form - Kp



Humic A	Thick dark brown powdery humic sandy clay loam to clay
Yellow apedal B	Porous non-structured yellow-brown clay loam
Red apedal B	Dark red porous friable sandy clay loam to non-structured clay

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone Vryheid sediments Dwyka tillite Dolerite	Kipipiri	Sandy clay loam	More than 1 000
		Kranskop	Clay loam	
		Umbumbulu	Clay	

FEATURES TO NOTE

- physical properties : good
- lime and gypsum : most commonly required to correct aluminium toxicity and deficiencies of calcium and magnesium
- phosphorus or zinc : commonly required to correct serious deficiencies
- potassium : requirement may be higher than average
- nitrogen : requirement should be below average
- silicon : good responses have been obtained to calcium silicate slag
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils
- other families : soils previously known as 'humic phase' Griffins are now accommodated in a family with thin humic A horizons

SELECTED PROPERTIES OF ARCADIA FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Rydalvale	More than 50	100 to 140	Medium to poor	Moderate	Low to moderate	cl, sh
Rooidraai	More than 50	100 to 140	Medium to poor	Moderate	Low	cl, sh
Arcadia	More than 50	100 to 140	Poor	Poor	Low to moderate	cl, sh
Eenzaam	More than 50	100 to 140	Poor	Poor	Low	cl, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Rydalvale	6,0 to 7,5	High	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Moderate
Rooidraai	6,0 to 7,5	High	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Moderate
Arcadia	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Very high
Eenzaam	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Very high

*Free lime present

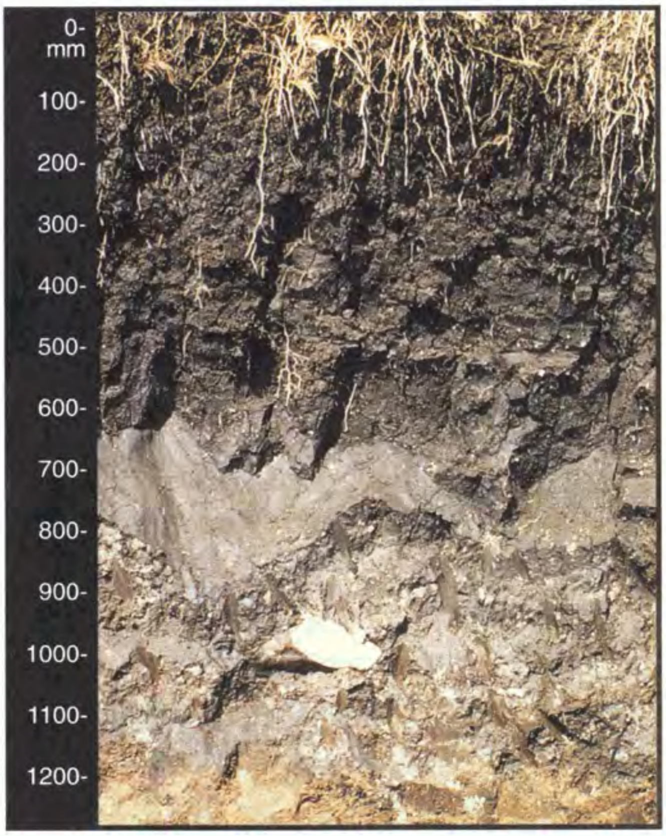
Correlation FAO

Chromic Vertisols

Correlation USDA

Vertisols

Arcadia Form - Ar

Vertic A		Black or reddish-brown cracking blocky clay
Unspecified		Weathered rock

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Dolerite Tugela schist Cretaceous sediments	Rydalvale	Black clay	
		Rooidraai	Red clay	
Dry Lowveld Humid Lowveld	Swaziland basic rocks	Rydalvale	Black clay	300 to 1 100
Dry Lowveld	Dolerite-basalt Cretaceous sediments	Arcadia (calcareous)	Black clay	
		Eenzaam (calcareous)	Red clay	

FEATURES TO NOTE

- heavy cracking clay : cannot be worked when too wet or too dry
- irrigation : intake rates are slow in moist soils
- salinity hazard : can occur in the Lowveld System where good drainage and irrigation scheduling are necessary
- nutrient status : good
- trashing : good responses to a trash blanket under rainfed conditions
- irrigation : intake rates are slow in moist soils
- harvest : preferably in the drier winter months

SELECTED PROPERTIES OF RENSBURG FORM SOIL SERIES

Soil series	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Phoenix	More than 40	80 to 140	Poor	Very poor	Moderate	cl, mw
Rensburg	More than 40	80 to 140	Poor	Very poor	Moderate	cl, mw

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Phoenix	6,0 to 7,5	High	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Moderate to high
Rensburg	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	High

*Free lime present

Correlation FAO

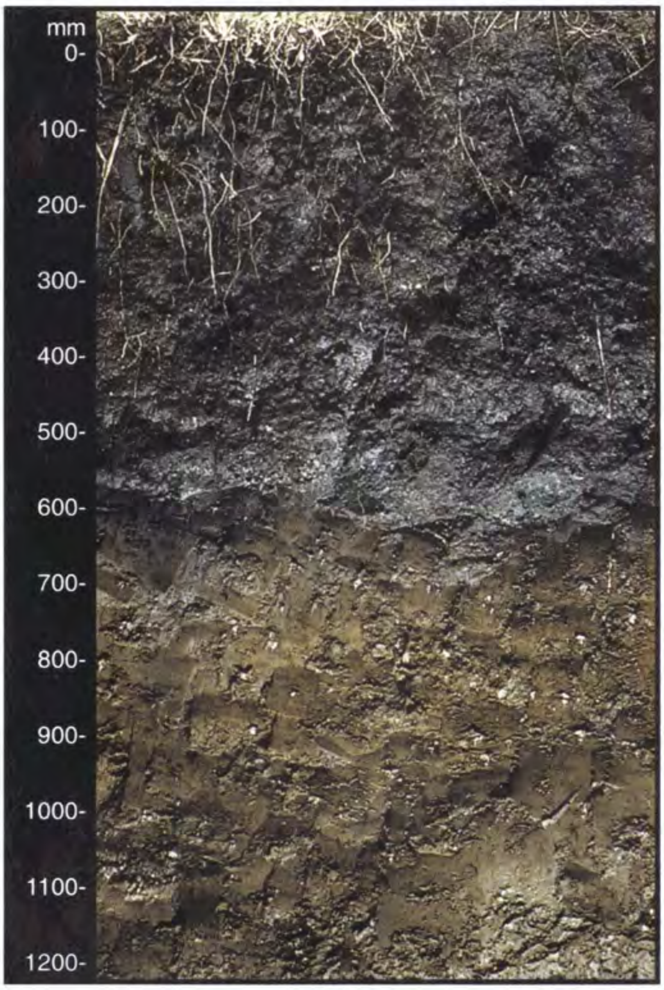
Chromic Vertisols (dark, with gleyic horizon)

Correlation USDA

Vertisols

Rensburg Form - Rg

Vertic A	Black cracking blocky clay
G horizon	Greyish-yellow mottled clay (gley) with water table



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Alluvium Pietermaritzburg shales Vryheid sediments Dolerite-basalt Tugela schist	Phoenix	Clay	400 to 800
Dry Lowveld Humid Lowveld	Alluvium Dolerite-basalt Swaziland basic rocks	Rensburg (calcareous)	Clay	

FEATURES TO NOTE

- drainage : poor
- irrigation : generally not recommended, but where practised good irrigation scheduling is essential
- salinity hazard : can exist in the Rensburg series
- timing : work only in the dry winter months
- trashing : a trash blanket may aggravate drainage problems

SELECTED PROPERTIES OF INHOEK FORM SOIL SERIES

Soil series	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Cromley	Less than 35	100 to 140	Medium	Moderate to good	Moderate to low	cl
Coniston	More than 35	140 to 180	Medium	Moderate	Moderate to low	cl
Inhoek	Less than 35	100 to 140	Medium	Moderate	Moderate to low	cl
Drydale	More than 35	140 to 180	Medium	Moderate to poor	Moderate to low	cl

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Cromley	6,0 to 7,0	High	Absent	Low	Moderate	Moderate	Moderate to high	Moderate to high	Low
Coniston	6,0 to 7,0	High	Absent	Low	Moderate	Moderate to high	Moderate to high	Moderate to high	Low
Inhoek	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate to high	Low to moderate
Drydale	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate to high	Moderate to high	Moderate to high	Moderate

*Free lime present

Correlation FAO

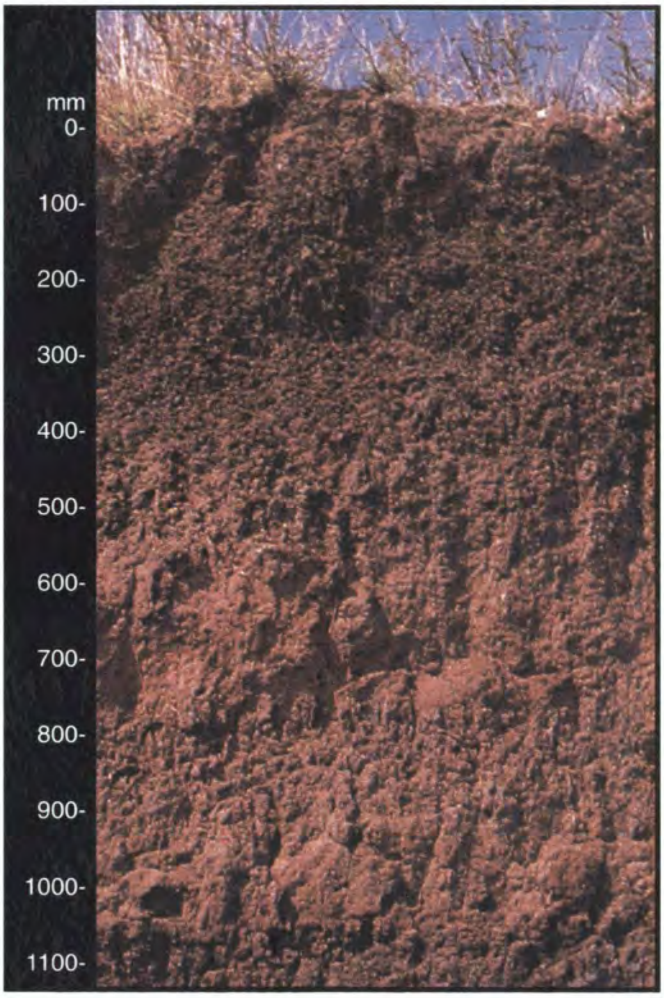
Haplic Phaeozems
Chernozems (possibly)
(all on stratified alluvium)

Correlation USDA

Mollisols

Inhoek Form - Ik

Melanic A	Dark grey to black blocky clay
Stratified alluvium or Neocutanic B	Recent stratified alluvium or olive-brown weakly structured clay



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Alluvium	Cromley	Clay loam	More than 1 000
		Coniston	Clay	
Dry Lowveld	Alluvium	Inhoek (calcareous)	Clay loam	
		Drydale (calcareous)	Clay	

FEATURES TO NOTE

- productivity : high; a good soil in every respect
- nutrient status : good
- soil tilth : soil should not be worked when too wet or too dry
- salinity hazard : exists in the Drydale series
- harvest : preferably in the drier months

SELECTED PROPERTIES OF MILKWOOD FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Dansland	15 to 35	100 to 180	Medium	Moderate	Low to moderate	cl, sh
Milkwood	More than 35	100 to 140	Medium	Moderate	Moderate to low	cl, sh
Sunday	15 to 35	100 to 140	Medium to poor	Moderate to poor	Moderate to low	cl, sh
Graythorne	More than 35	100 to 140	Medium to poor	Moderate to poor	Moderate to low	cl, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Dansland	5,5 to 7,0	High	Absent	Low	Moderate	Moderate	Moderate to high	Moderate to high	Low
Milkwood	5,5 to 7,0	High	Absent	Low	Moderate	Moderate	Moderate to high	Moderate to high	Low
Sunday	7,0 to 8,5	Very high*	Absent	Low	Moderate	Moderate	Moderate to high	Moderate to high	Moderate to high
Graythorne	7,0 to 8,5	Very high*	Absent	Low	Moderate	Moderate	Moderate to high	Moderate to high	Moderate to high

*Free lime present

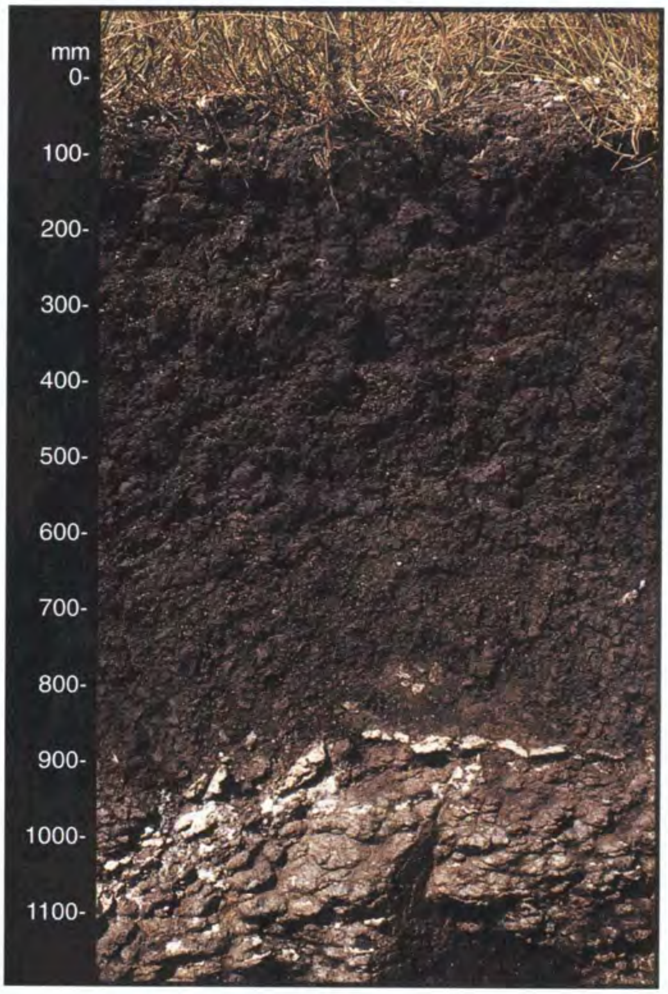
Correlation FAO

Haplic Phaeozems
Haplic and Calcic Chernozems

Correlation USDA

Mollisols

Milkwood Form - Mw



Melanic A	Dark greyish-black blocky clay sometimes with fragments of shale
Hard rock	Rock

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Amphibolite Pietermaritzburg shales Vryheid sediments Tarkastad sediments	Dansland	Clay loam	300 to 700
		Milkwood	Clay	
Dry Lowveld	Swaziland basic rocks Vryheid sediments Basalt	Sunday (calcareous)	Clay loam	
		Greythorne (calcareous)	Clay	

FEATURES TO NOTE

- drought problems : cane is frequently droughted
- salinity hazard : can exist in the Graythorne and Sunday series
- soil tilth : soil should not be worked when too wet or too dry
- trashing : good responses to a trash blanket under rainfed conditions
- harvest : preferably in the drier months

SELECTED PROPERTIES OF TAMBANKULU FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Fenfield	15 to 35	100 to 140	Poor	Poor	Low	mw
Tambankulu	More than 35	100 to 140	Poor	Poor	Low	cl, mw
Loshoek	15 to 35	100 to 140	Poor	Poor	Moderate to low	mw
Masala	More than 35	100 to 140	Poor	Poor	Moderate to low	cl, mw

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Fenfield	6,0 to 7,0	High	Absent	Low	Moderate	Moderate to low	Moderate to high	Moderate to high	Low to moderate
Tambankulu	6,0 to 7,0	High	Absent	Low	Moderate	Moderate to low	Moderate to high	Moderate to high	Low to moderate
Loshoek	7,0 to 8,5	Very high*	Absent	Low to moderate	Moderate	Moderate to low	Moderate to high	Moderate to high	Moderate to high
Masala	7,0 to 8,5	Very High*	Absent	Low to moderate	Moderate	Moderate to low	Moderate to high	Moderate to high	Moderate to high

*Free lime present

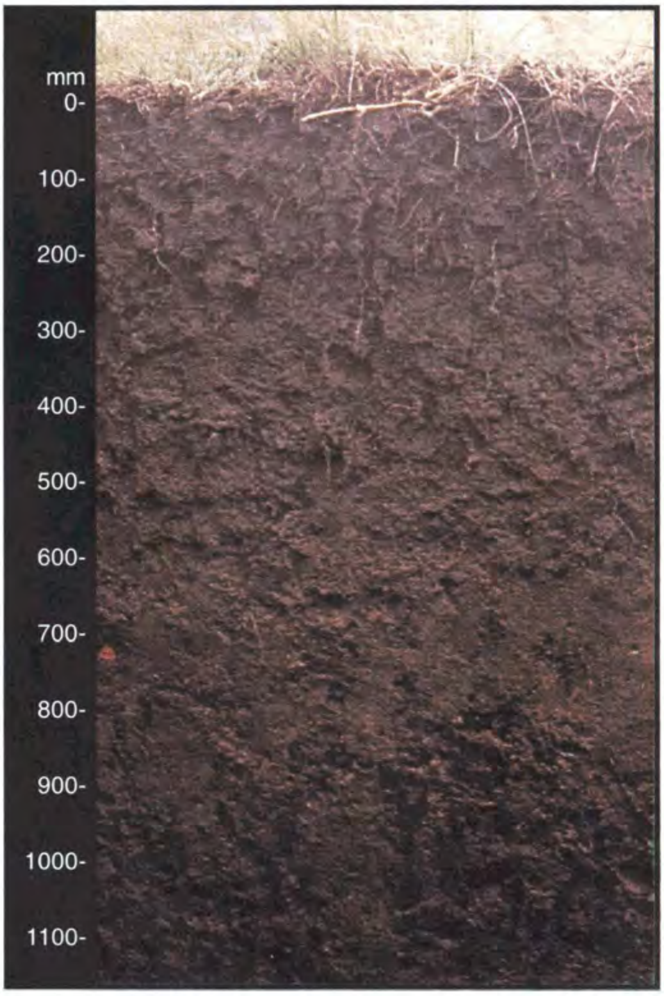
Correlation FAO

Plinthic Castanozems

Correlation USDA

Mollisols

Tambankulu Form - Tk

Melanic A		Dark grey to black blocky clay
Soft plinthic B		Mottled and gleyed with ironstone concretions; intermittent water table

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Hinterland	Alluvium	Fenfield	Clay loam	300 to 800
		Tambankulu	Clay	
Dry Lowveld	Dolerite-basalt Alluvium	Loshoek (calcareous)	Clay loam	
		Masala (calcareous)	Clay	

FEATURES TO NOTE

- shallow with drainage problems : irrigation control must be good with provision of subsurface drains
- salinity hazard : in the Masala and Loshoek series, soil sampling for salinity/sodicity is necessary
- soil tilth : should not be worked when too wet or too dry
- nitrogen requirements : optimum levels are higher than average
- harvest : preferably in the drier months

SELECTED PROPERTIES OF MAYO FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Mayo	15 to 35	100 to 180	Medium to good	Moderate to good	Moderate to low	cl, sh
Msinsini	More than 35	100 to 180	Medium	Moderate	Low to moderate	cl, sh
Tshipise	15 to 35	100 to 180	Medium	Moderate	Moderate to low	cl, sh
Pafuri	More than 35	100 to 180	Medium	Moderate	Low to moderate	cl, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Mayo	5,5 to 7,0	Moderate	Absent	Low	Moderate	Moderate to high	Low to moderate	Low to moderate	Low
Msinsini	5,5 to 7,0	Moderate	Absent	Low	Moderate	Moderate to high	Low to moderate	Low to moderate	Low
Tshipise	7,0 to 8,5	High*	Absent	Low	Moderate	Moderate	Low to moderate	Low to moderate	Moderate
Pafuri	7,0 to 8,5	High*	Absent	Low	Moderate	Moderate	Low to moderate	Low to moderate	Moderate

*Free lime present

Correlation FAO

Haplic Phaeozems
Castanozems

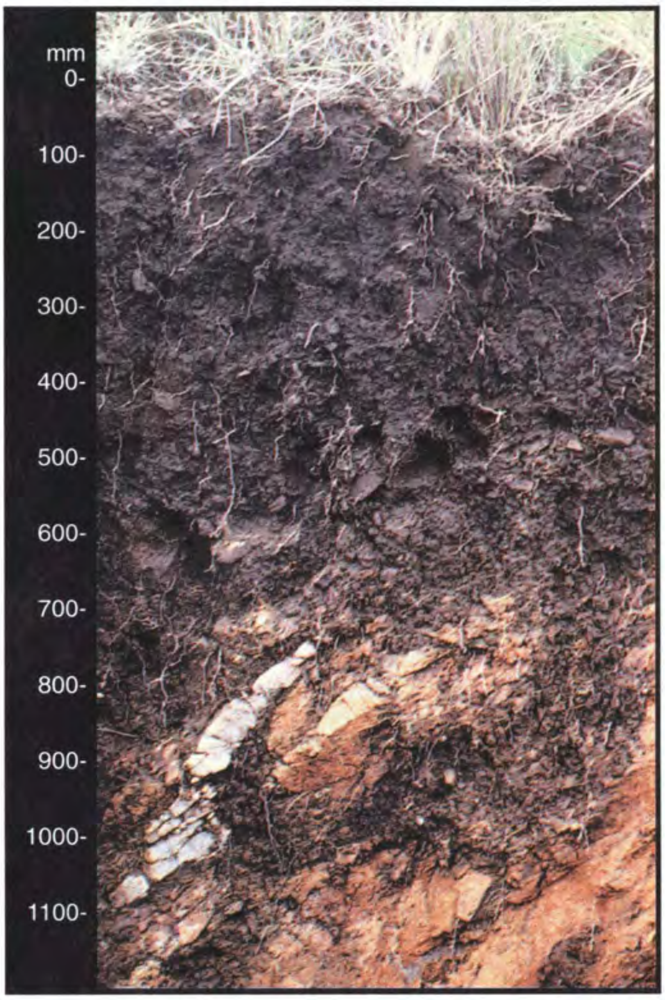
Correlation USDA

Mollisols

Mayo Form - My

Melanic
A

Lithocutanic
B



Dark
greyish-black
blocky clay

Soil tongues
into
weathering
rock

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Granite	Mayo	Coarse sandy clay loam	500 to 1 200
		Msinsini	Sandy clay	
Dry Lowveld	Granite	Tshipise (calcareous)	Coarse sandy clay loam	
		Pafuri (calcareous)	Sandy clay	

FEATURES TO NOTE

- good physical features : roots penetrate into clay tongues
- salinity hazard : exists in the Tshipise and Pafuri series
- soil tilth : should not be worked when too wet or too dry
- trashing : under rainfed conditions a good response to a trash blanket can be obtained

SELECTED PROPERTIES OF BONHEIM FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Kiora	15 to 35	100 to 140	Medium to good	Moderate to good	Low	cl
Stanger	More than 35	100 to 140	Medium	Moderate	Low	cl
Rasheni	More than 35	100 to 140	Medium	Moderate to poor	Low	cl
Glengazi	More than 35	100 to 140	Medium to poor	Moderate to poor	Low to moderate	cl
Bonheim	More than 35	100 to 140	Medium to poor	Moderate to poor	Moderate to low	cl

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Kiora	5,0 to 6,0	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Low	Low
Stanger	5,5 to 7,5	High	Absent	Low to moderate	Moderate to high	Moderate	Moderate	Moderate	Low
Rasheni	7,0 to 8,5	High to very high*	Absent	Low to moderate	Moderate to high	Moderate	Moderate	Moderate	Moderate to high
Glengazi	5,5 to 7,5	High to very high	Absent	Low to moderate	Moderate to high	Moderate	Moderate	Moderate	Moderate to high
Bonheim	7,0 to 8,5	High to very high*	Absent	Low to moderate	Moderate to high	Moderate	Moderate	Moderate	Moderate to high

*Free lime present

Correlation FAO

Luvic Phaeozems
Chernozems

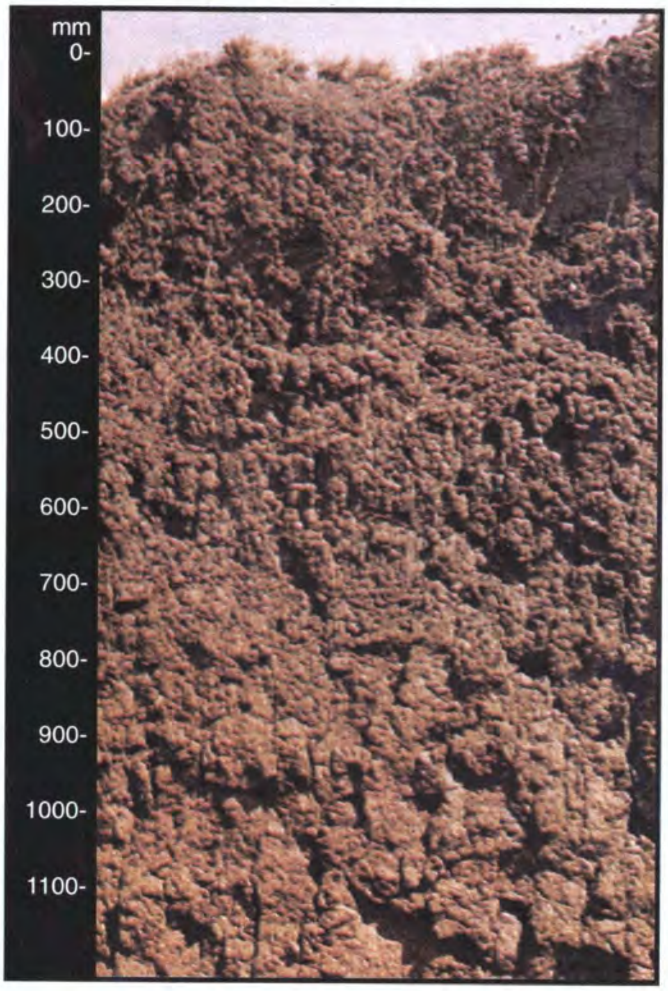
Correlation USDA

Mollisols

Bonheim Form - Bo

Melanic
A

Pedocutanic
B



Black
blocky clay

Yellow-brown
or red
blocky clay
with
variegated
colours

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands Dry Lowveld	Dolerite-basalt	Kiora	Sandy clay loam	800 to 1 200
		Stanger	Clay	
		Rasheni (calcareous)	Clay	
Coastal Lowlands	Alluvium Pietermaritzburg shales Vryheid sediments Cretaceous sediments	Glengazi	Clay	400 to 800
Dry Lowveld	Alluvium Dolerite-basalt Cretaceous sediments Vryheid sediments	Bonheim (calcareous)	Clay	

FEATURES TO NOTE

- salinity hazard : with yellow-brown subsoils, drainage is poor and salinity-sodicity high; subsurface drainage and good irrigation control essential
- trashing : good responses to a trash blanket on the Stanger and Kiora series
- a red subsoil : indicates good drainage with no management problems
- harvest : preferably in the drier months on the Glengazi and Bonheim series

SELECTED PROPERTIES OF WILLOWBROOK FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Emfuleni	15 to 35	100 to 140	Poor	Very poor	Moderate to low	cl
Willowbrook	More than 35	100 to 140	Poor	Very poor	Moderate to low	cl
Sarasdale	15 to 35	100 to 140	Poor	Very poor	Moderate to low	cl
Chinyika	More than 35	100 to 140	Poor	Very poor	Moderate to low	cl

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Emfuleni	5,5 to 7,0	High	Absent	Low	Moderate	Moderate	Moderate	Moderate to high	Moderate
Willowbrook	5,5 to 7,0	High	Absent	Low	Moderate	Moderate	Moderate	Moderate to high	Moderate
Sarasdale	7,0 to 8,5	Very high*	Absent	Low	Moderate	Moderate	Moderate	Moderate to high	Moderate to high
Chinyika	7,0 to 8,5	Very high*	Absent	Low	Moderate	Moderate	Moderate	Moderate to high	Moderate to high

*Free lime present

Correlation FAO

Blevic Phaeozems

Correlation USDA

Mollisols

Willowbrook Form - Wo

Melanic A	Black blocky clay
G horizon	Dark grey or yellow mottled clay (gley) with water table

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands Humid Lowveld	Pietermaritzburg shales Vryheid sediments Tarkastad sediments Amphibolite Alluvium	Emfuleni	Clay loam	400 to 700
		Willowbrook	Clay	
Dry Lowveld	Vryheid sediments Tarkastad sediments Alluvium	Sarasdale (calcareous)	Clay loam	
		Chinyika (calcareous)	Clay	

FEATURES TO NOTE

- drainage : very poor
- irrigation : generally not recommended, but where practised good irrigation scheduling is essential
- salinity hazard : problems are likely in the Sarasdale and Chinyika series
- timing : land preparation in the dry winter months only
- trashing : a trash blanket may aggravate drainage problems

SELECTED PROPERTIES OF MISPAH FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Mispah	6 to 35	Less than 80	Medium	Moderate	Moderate to high	cr, co, mw, sh
Muden	15 to 35	Less than 80	Medium	Moderate	Moderate to high	cr, co, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Mispah	4,5 to 7,0	Low to moderate	Low to** moderate	Low to moderate	Low to moderate	Low	Low	Low	Low to*** moderate
Muden	7,0 to 8,5	High*	Absent	Low	Low to moderate	Low	Low	Low	Low to*** moderate

*Free lime present **Moderate in Mistbelt System only ***Moderate in Dry Lowveld System only

Correlation FAO

Lithosols

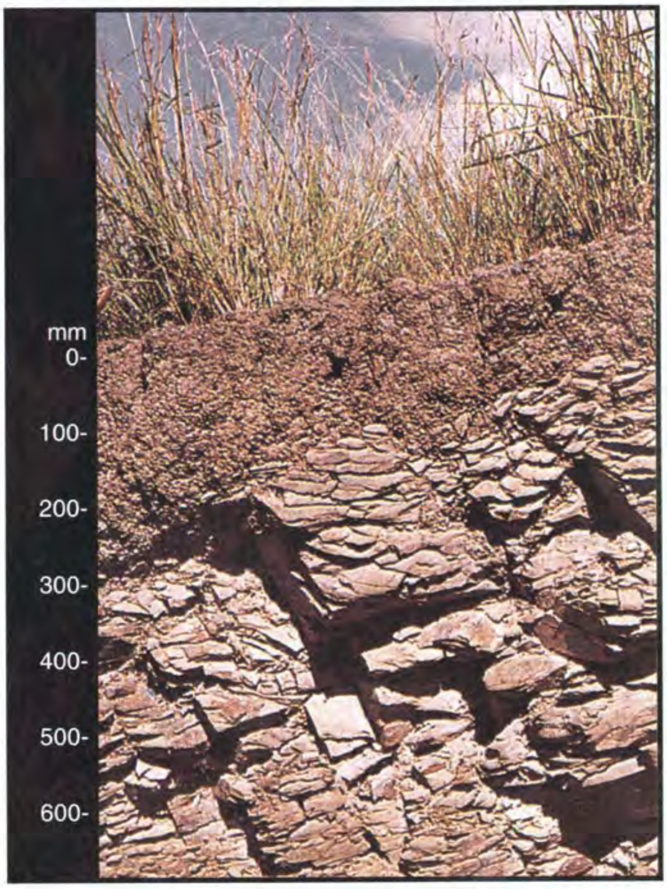
Correlation USDA

Aridisols

Mispah Form - Ms

Orthic A

Hard rock



Very shallow grey to brown sand to sandy clay loam

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems except Coastal Sands	Cave sandstone	Mispah	Fine sandy loam	150 to 500
	Tarkastad sediments		Clay loam	
	Swaziland quartzite Vryheid sediments		Sandy loam to sandy clay loam	
Dry Lowveld	Swaziland shales and limestones	Muden (calcareous)	Sandy clay loam	

FEATURES TO NOTE

- non-arable : when effective rooting depth is less than 400 mm
- shallow profile : soil moisture retention is limited
- planting : use minimum tillage and planting in the interrow, preferably with filtercake in a vertically mulched slot
- erodibility : protect soils with a trash blanket or scattered tops
- low nutrient status : high fertiliser rates would not generally be warranted because of the overriding limitations of soil depth and available moisture

SELECTED PROPERTIES OF WESTLEIGH FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Kosi	0 to 6 (medium sand)	80 to 100	Medium to poor	Poor to very poor	Very high	cr, co, mw, sh
Witsand	6 to 15 (medium sand)	80 to 100	Medium to poor	Poor to very poor	High	cr, co, sh
Rietvlei	15 to 35 (fine sand)	100 to 140	Medium to poor	Poor to very poor	High	cl, cr, co, mw, sh
Sibasa	More than 35 (undifferentiated)	100 to 140	Medium to poor	Poor to very poor	High to moderate	cl, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Kosi	5,0 to 7,0	Very low	Low	Low	Low	Low	Low	Low	Low to moderate
Witsand	6,0 to 8,0	Low	Absent	Low	Low	Low	Low	Low	Low to moderate
Rietvlei	6,0 to 8,0	Low to moderate	Absent	Low	Low	Low	Low	Moderate	Moderate
Sibasa	6,0 to 8,0	Moderate	Absent	Low	Low	Low	Low to moderate	Moderate	Moderate

Correlation FAO

Plinthic Acrisols
Luvisols (plinthic and argilluvic horizons coincide)

Correlation USDA

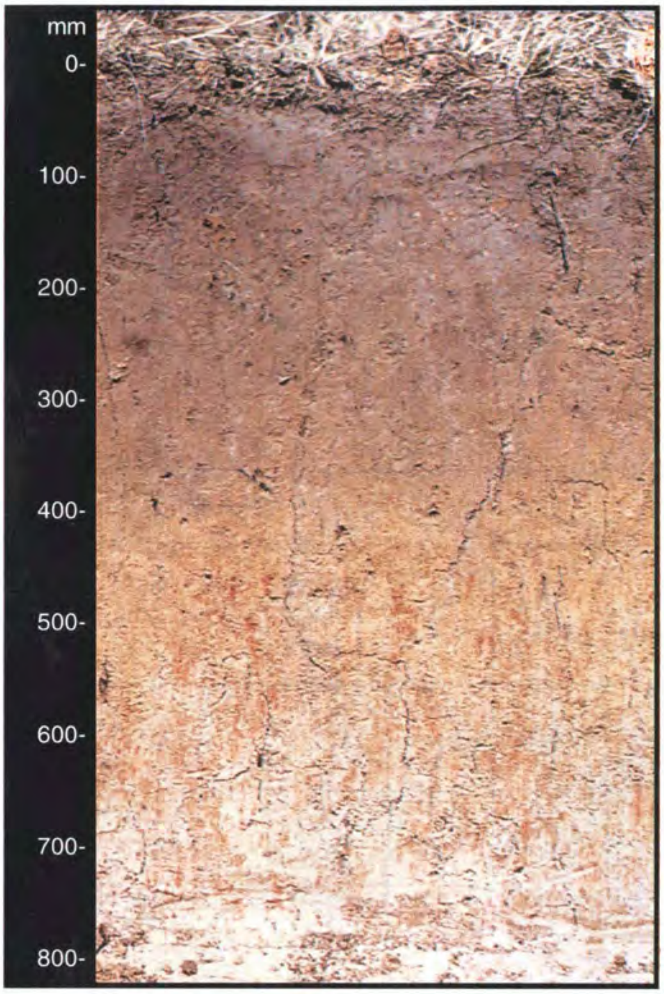
Alfisols
Inceptisols

FEATURES TO NOTE

- field layout : good conservation layouts based on strip cropping and minimum tillage are recommended
- erodibility : the easily dispersed topsoil is highly erodible, so fields should be well protected; use minimum tillage and protect with trash or scattered tops
- salinity hazard : poor drainage may lead to salinity problems in the Rietvlei and Sibasa series in the Dry Lowveld System
- low available water capacity : exceptionally good surface water management and irrigation scheduling are required
- planting : in low lying wet areas planting on the ridge is desirable
- nematodes : nematicides are likely to be effective in the sandy Kosi series only
- low nutrient status : nutrients are inherently low including calcium, magnesium and zinc; higher than average fertiliser levels are required and split applications of nitrogen and potassium are recommended; leaf sampling is strongly recommended
- timing : because of wetness, compaction and capping problems, it is preferable to harvest in winter

Westleigh Form - We

Orthic A		Grey sand to sandy clay loam
Soft plinthic B		Mottled and gleyed with soft iron concretions



MAIN SOIL SERIES, TEXTURE AND DEPTH

<table>
<tr><th>Soil system</th><th>Parent material</th><th>Soil series</th><th>Topsoil texture</th><th>Effective rooting depth (mm)</th></tr>
<tr><td>Coastal Sands</td><td>Recent Sands</td><td>Kosi</td><td>Medium sand</td><td rowspan="5">300 to 500</td></tr>
<tr><td rowspan="4">Coastal Lowlands
Dry Lowveld</td><td>Natal Group Sandstone</td><td>Witsand</td><td>Medium loamy sand</td></tr>
<tr><td>Vryheid sediments</td><td>Rietvlei</td><td>Fine sandy loam</td></tr>
<tr><td>Dwyka tillite</td><td>Sibasa</td><td>Fine/medium sandy clay loam</td></tr>
</table>

SELECTED PROPERTIES OF DRESDEN FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Tevreden	15 to 35	80 to 140	Medium to poor	Poor	High	cr, co, mw, sh
Hilldrop	15 to 35	80 to 140	Medium to poor	Poor	High	cr, co, mw, sh

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Tevreden	6,0 to 7,5	Low	Absent	Low	Low	Low	Low	Low	Low to moderate
Hilldrop	6,0 to 7,5	Low	Absent	Low	Low	Low	Low	Low	Low to moderate

NF - new form in this bulletin

Correlation FAO

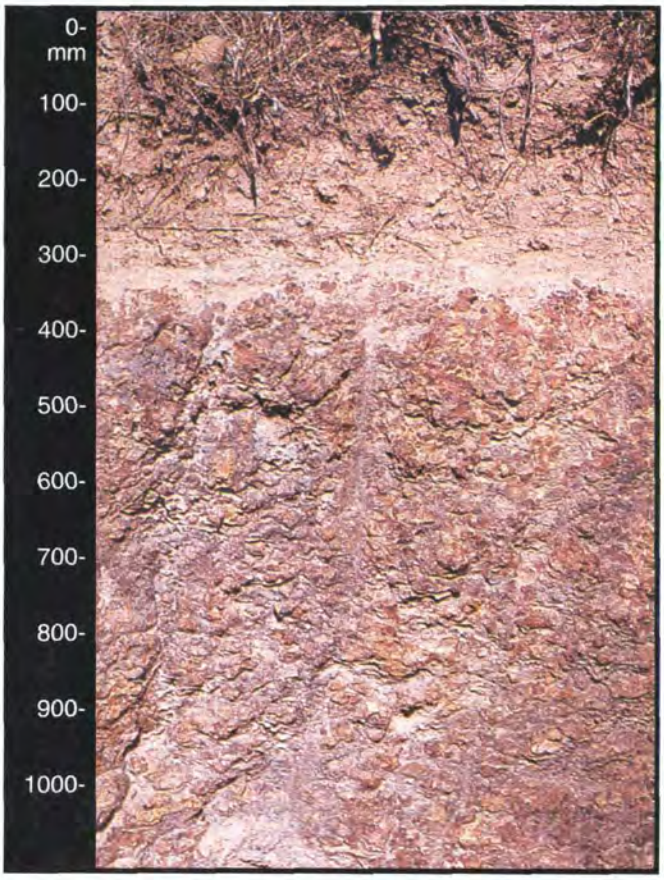
Plinthic Acrisols

Correlation USDA

Alfisols

Dresden Form - Dr

Orthic A	Grey to brown sand to sandy clay loam
Hard plinthic B	Impermeable hard plinthic layer



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features	Effective rooting depth (mm)
Coastal Lowlands Hinterland	Dwyka tillite Natal Group Sandstone	Tevreden	A horizon non-bleached	300 to 500
		Hilldrop	A horizon bleached	

FEATURES TO NOTE

- non-arable : when effective rooting depth is less than 400 mm
- erodibility : the easily dispersed topsoil is highly erodible, so lands should be well protected; use minimum tillage and protect with trash or scattered tops
- poorly drained : this may lead to salinity problems on soils derived from Dwyka tillite
- low available water capacity : exceptionally good surface water management and irrigation scheduling are required
- planting : in low lying wet areas planting on the ridge is desirable
- low nutrient status : nutrients are inherently low including calcium, magnesium and zinc; higher than average fertiliser levels are required and split applications of nitrogen and potassium are recommended; leaf sampling is strongly recommended
- timing : because of wetness, compaction and capping problems, it is preferable to harvest in winter

SELECTED PROPERTIES OF GLENROSA FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Platt	6 to 15 (medium sand)	80 to 100	Good	Good	High	cr, co, mw, sh
Glenrosa	6 to 15 (coarse sand)	80 to 100	Good	Good	High	cr, co, mw, sh
Williamson	15 to 35 (fine sand)	100 to 140	Medium	Moderate to good	High	cl, cr, co, mw, sh
Trevanian	15 to 35 (medium sand)	100 to 180	Good	Good	Low to moderate	cl, cr, co
Robmore	15 to 35 (coarse sand)	100 to 140	Medium	Moderate	Low to moderate	cl, cr, co
Saintfaiths	More than 35 (undifferentiated)	100 to 140	Medium	Moderate	Low	cl, co, mw
Achterdam	15 to 35 (sandy clay loam)	100 to 140	Medium	Moderate	Low to moderate	cl, cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Platt	5,0 to 6,0	Low	Low	Low	Low	Low	Low	Moderate	Low
Glenrosa	5,0 to 6,0	Low	Low	Low	Low	Low	Low	Moderate	Low
Williamson	5,0 to 6,5	Low	Low	Low	Low to moderate	Low	Low	Moderate	Low
Trevanian	5,0 to 6,0	Low to moderate	Low to moderate	Low	Low to moderate	Moderate to high	Low	Low	Low
Robmore	6,0 to 7,0	Moderate	Absent	Low	Low	Moderate	Moderate	High	Low
Saintfaiths	6,0 to 7,0	Moderate to high	Absent	Low to moderate	Low	Low to moderate	Moderate	High	Low
Achterdam	7,0 to 8,5	High*	Absent	Low to moderate	Low	Low	Moderate	Moderate	Moderate

*Free lime present

Correlation FAO

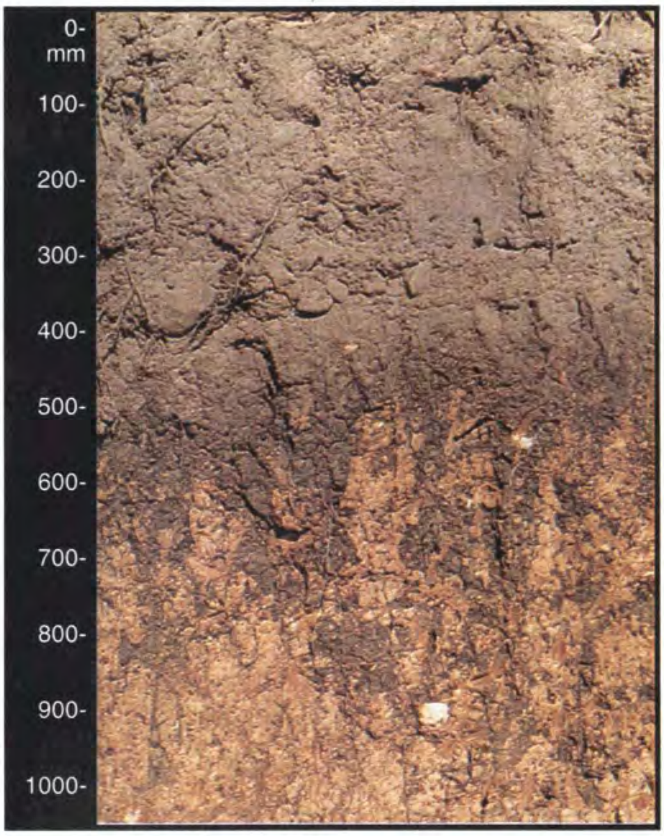
Ochric Cambisols
Lithosols

Correlation USDA

Inceptisols
Aridisols

Glenrosa Form - Gs

Orthic A	Shallow grey or dark grey loamy sand to clay
Lithocutanic B	Soil tongues into weathering rock
Saprolite	Weathering rock



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Natal Group Sandstone	Platt	Medium loamy sand	500 to 700
	Granite	Glenrosa	Coarse loamy sand	
	Dwyka tillite	Williamson	Fine sandy clay loam	
	Granite	Robmore	Coarse sandy loam	
Hinterland Mistbelt	Natal Group Sandstone	Trevanian	Medium sandy loam	600 to 900
	Dwyka tillite	Saintfaiths	Clay	
Dry Lowveld	Swaziland basic rocks Basalt	Saintfaiths	Clay	400 to 700
		Achterdam (calcareous)	Sandy clay loam	
	Granite	Glenrosa	Coarse loamy sand	

FEATURES TO NOTE

- field layout : good conservation layouts based on strip cropping and minimum tillage are recommended
- high erodibility : needs a protective cover such as a trash blanket or burnt tops
- irrigation : because of relatively shallow profiles in granite derived soils in the lowveld, careful irrigation scheduling is essential; profiles derived from Swaziland basic rocks are highly suitable for irrigation
- planting : use minimum tillage with planting in the interrow, preferably in a vertically mulched slot with filtercake
- moderate nutrient status : above average levels of nutrients are generally required for the Platt, Glenrosa and Williamson series, but lower than average amounts of nitrogen are required for the Trevanian series; leaf sampling strongly recommended
- green manuring : strongly recommended where summer fallows are practised

SELECTED PROPERTIES OF OAKLEAF FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Sezela	0 to 6 (coarse sand)	80 to 100	Good	Excessive	High	mw
Levubu	6 to 15 (medium sand)	80 to 100	Good	Excessive	Moderate	cr, co, mw
Jozini	15 to 35 (undifferentiated)	100 to 180	Good	Good	Low	cl, cr, co
Koedoesvlei	More than 35 (undifferentiated)	140 to 180	Good	Moderate to good	Low	cl, cr, co
Leeufontein	15 to 35 (undifferentiated)	100 to 180	Good	Moderate to good	Low	cl, cr, co
Limpopo	15 to 35 (undifferentiated)	100 to 180	Good	Good	Low	cl, cr, co
Highflats	More than 35 (undifferentiated)	140 to 180	Good	Good	Low	cl, cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Sezela	6,0 to 7,0	Very low	Absent	Low to moderate	Low	Low	Low	Low	Absent
Levubu	6,0 to 7,0	Low	Absent	Low to moderate	Low	Low to moderate	Low to moderate	Low	Low
Jozini	6,0 to 7,0	Low to moderate	Absent	Low to moderate	Moderate	Low to moderate	Low to moderate	Low to moderate	Low
Koedoesvlei	6,0 to 7,0	Low to moderate	Absent	Low to moderate	Moderate	Low to moderate	Low to moderate	Low to moderate	Low
Leeufontein	6,0 to 7,0	Low to moderate	Absent	Low to moderate	Moderate to high	Low to moderate	Low to moderate	Low to moderate	Low
Limpopo	7,0 to 8,5	High*	Absent	Low	High	Moderate	Moderate	Moderate	Moderate to high
Highflats	4,5 to 6,0	Low to moderate	Moderate	Moderate	High	Moderate to high	Low	Low	Absent

*Free lime present

Correlation FAO

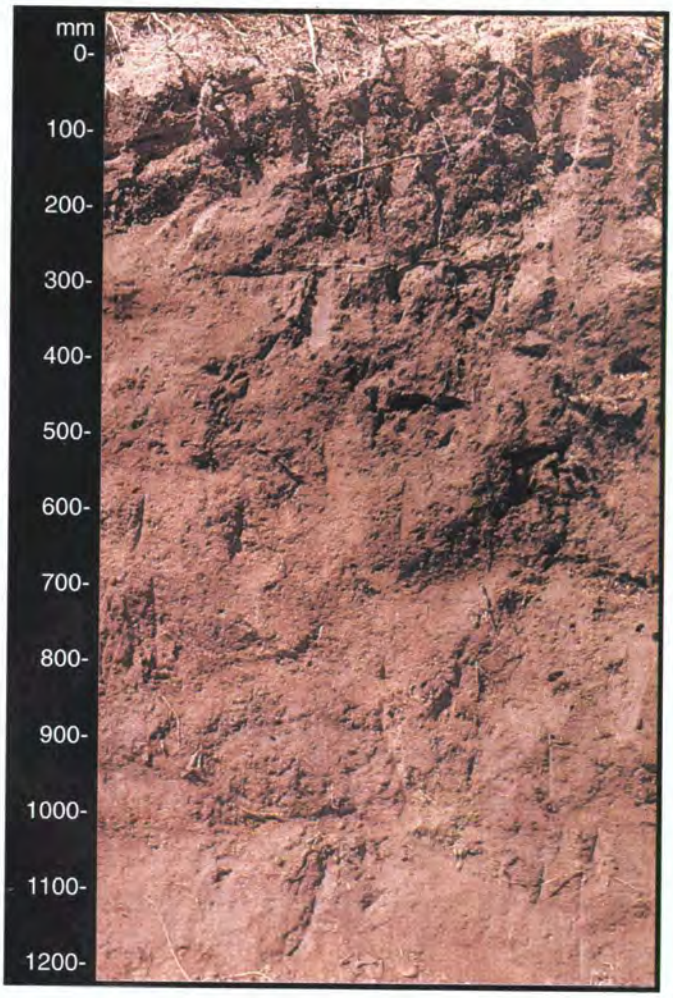
Ochric, Eutric and Calcic Cambisols

Correlation USDA

Inceptisols
Aridisols

Oakleaf Form - Oa

Orthic A	Dark grey-brown sand to sandy clay loam
Neocutanic B	Weakly structured dark brown, variegated, or red sandy loam to clay
Non-diagnostic Saprolite	Non-diagnostic weathering rock



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Colour (subsoil)	Effective rooting depth (mm)
River Valley Dry Lowveld	Alluvium	Sezela	Coarse sand	Dark brown or variegated	More than 800
		Levubu	Medium loamy sand		
		Jozini	Sandy loam		
		Koedoesvlei	Sandy clay loam		
Dry Lowveld	Alluvium	Limpopo (calcareous)	Sandy loam		
		Leeufontein	Sandy loam	Red	
Mistbelt	Natal Group Sandstone Alluvium	Highflats	Sandy clay loam		

FEATURES TO NOTE

- physical and chemical properties : good
- nematodes : only in the sandy Sezela series is the need for nematicides likely
- varieties : these alluvial derived soils are well suited to high potential varieties
- nutrition : generally poorly supplied with nutrients, so above average amounts of fertiliser needed
- soil compaction : may be a problem where there is a high proportion of silt and fine sand

SELECTED PROPERTIES OF TUKULU FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Olivedale	5 to 35	80 to 140	High	Good	Low to moderate	cl, cr, co, mw
Dikeni	5 to 35	80 to 140	High	Good	Low to moderate	cl, cr, co, mw
Scheepersrus	5 to 35	80 to 140	High	Good	Low to moderate	cl, cr, co, mw
Zandvliet	5 to 35	80 to 140	High	Good	Low to moderate	cl, cr, co, mw

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Olivedale	5,0 to 7,0	Very low	Low	Low	Low	Low	Low	Low	Absent
Dikeni	5,0 to 7,0	Low	Low	Low	Low	Low	Low to moderate	Low	Absent
Scheepersrus	6,0 to 7,0	Low to moderate	Absent	Low to moderate	Moderate	Low to moderate	Moderate	Low to moderate	Absent
Zandvliet	6,0 to 7,0	Low to moderate	Absent	Low to moderate	Moderate	Low to moderate	Moderate	Low to moderate	Absent

NF - new form in this bulletin

Correlation FAO

Ochric, Eutric and Calcic Cambisols

Correlation USDA

Aridisols

Tukulu Form - Tu

Orthic A	Dark grey-brown sand to sandy loam
Neocutanic B	Weak structured dark brown or red loamy sand to sandy clay
Unspecified material with signs of wetness	Signs of mottling

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features		Effective rooting depth (mm)
			A horizon	B horizon	
Coastal Sands Coastal Lowlands Hinterland Mistbelt	Recent Sands Alluvium Natal Group Sandstone	Olivedale	Non-bleached	Non-red	More than 800
		Dikeni		Red	
		Scheepersrus	Bleached	Non-red	
		Zandvliet		Red	

FEATURES TO NOTE

- physical and chemical properties : generally good
- productivity : often outyields similar Oakleaf form soils because of seepage water from higher up the slope
- nematodes : nematicides only required in the sandy soils
- varieties : these alluvial derived soils are well suited to high potential varieties
- nutrition : generally poorly supplied with nutrients, so above average amounts of fertiliser needed
- soil compaction : may be a problem where there is a high proportion of silt and fine sand

SELECTED PROPERTIES OF SWARTLAND FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Rosehill	15 to 35	80 to 140	Medium to poor	Moderate	Moderate to high	cl, cr, co
Swartland	35 to 55	100 to 140	Medium	Moderate	Moderate	cl, mw
Skilderkrans	35 to 55	100 to 140	Medium	Moderate	Moderate	cl, mw
Malakata	15 to 35	80 to 140	Medium to poor	Moderate to poor	Moderate to high	cl, cr, co
Nyoka	35 to 55	80 to 140	Medium to poor	Moderate to poor	Moderate	cl, mw
Broekspruit	35 to 55	80 to 140	Medium to poor	Moderate	Moderate	cl, mw

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Rosehill	5,0 to 6,0	Moderate	Low	Low to moderate	Low to moderate	Low	Moderate	Moderate	Low
Swartland	5,0 to 6,0	Moderate to high	Absent	Low to moderate	Low to moderate	Moderate	Moderate to high	Moderate to high	Low
Skilderkrans	5,0 to 6,0	Moderate to high	Absent	Low to moderate	Low to moderate	Moderate	Moderate to high	Moderate to high	Low
Malakata	7,0 to 9,0	High*	Absent	Low to moderate	Low to moderate	Low	Moderate	Moderate	Moderate
Nyoka	7,0 to 9,0	High*	Absent	Low to moderate	Low to moderate	Low	Moderate to high	Moderate to high	Moderate
Broekspruit	7,0 to 9,0	High*	Absent	Low to moderate	Low to moderate	Moderate	Moderate to high	Moderate to high	Moderate to high

*Free lime present

Correlation FAO

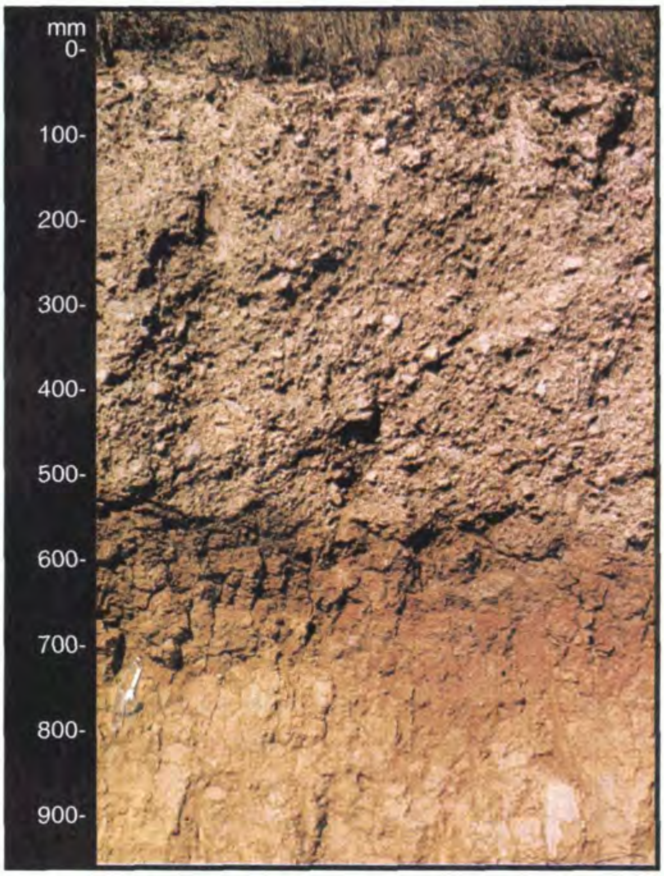
Brunic and Chromic Luvisols

Correlation USDA

Alfisols
Aridisols

Swartland Form - Sw

Orthic A	Grey to dark grey-brown fine sandy loam to sandy clay loam
Pedocutanic B	Grey-brown or red blocky clay with variegated colours
Saprolite	Soft decomposing rock



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Colour (subsoil)	Effective rooting depth (mm)
Coastal Lowlands	Vryheid sediments Tarkastad sediments	Rosehill	Fine sandy loam	Grey-brown	500 to 700
		Swartland	Fine sandy clay loam		700 to 1 200
		Skilderkrans	Fine sandy clay loam	Red	500 to 700
River Valley Dry Lowveld	Vryheid sediments Cretaceous sediments Tarkastad sediments	Malakata (calcareous)	Fine sandy clay loam	Grey-brown	500 to 700
		Nyoka (calcareous)	Fine sandy clay loam		300 to 500
		Broekspruit (calcareous)	Fine sandy clay loam	Red	300 to 500

FEATURES TO NOTE

- erodibilty : subsoils are often highly erodible with dispersive clays
- cover cropping : because these soils are low in organic matter and prone to erosion, cover cropping should be practised on summer fallow fields
- planting : use minimum tillage and plant in the interrow, in a vertically mulched slot containing filtercake
- irrigation : exceptionally good surface water management and irrigation scheduling are required
- salinity hazard : drainage and careful irrigation management required in the Lowveld
- trashing : under rainfed conditions a good response to a trash blanket can be obtained
- timing : prone to compaction; soils should not be worked when wet

SELECTED PROPERTIES OF VALSRIVIER FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Valsrivier	15 to 35	100 to 140	Medium	Moderate	Very high	cr, co
Lindley	35 to 55	100 to 140	Medium to poor	Moderate to poor	Moderate to high	cr, co
Sheppardvale	More than 55	140 to 180	Poor	Moderate to poor	Moderate to high	cl, cr, co
Arniston	35 to 55	100 to 140	Medium	Moderate	Moderate	cr, co
Waterval	35 to 55	100 to 140	Medium	Moderate	Moderate	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Valsrivier	6,0 to 9,0	Moderate to high*	Absent	Low to moderate	Low	Low to moderate	Low to moderate	Moderate	Moderate to high
Lindley	6,0 to 9,0	Moderate to high*	Absent	Low to moderate	Low	Low to moderate	Low to moderate	Moderate	Moderate to high
Sheppardvale	6,0 to 9,0	Moderate to high*	Absent	Low to moderate	Low	Low to moderate	Low to moderate	Moderate	Moderate to high
Arniston	6,0 to 7,0	Moderate	Absent	Low to moderate	Moderate	Moderate	Low to moderate	Moderate	Low to moderate
Waterval	6,0 to 7,0	Moderate	Absent	Low to moderate	Moderate	Moderate	Low to moderate	Moderate	Low to moderate

*Free lime present

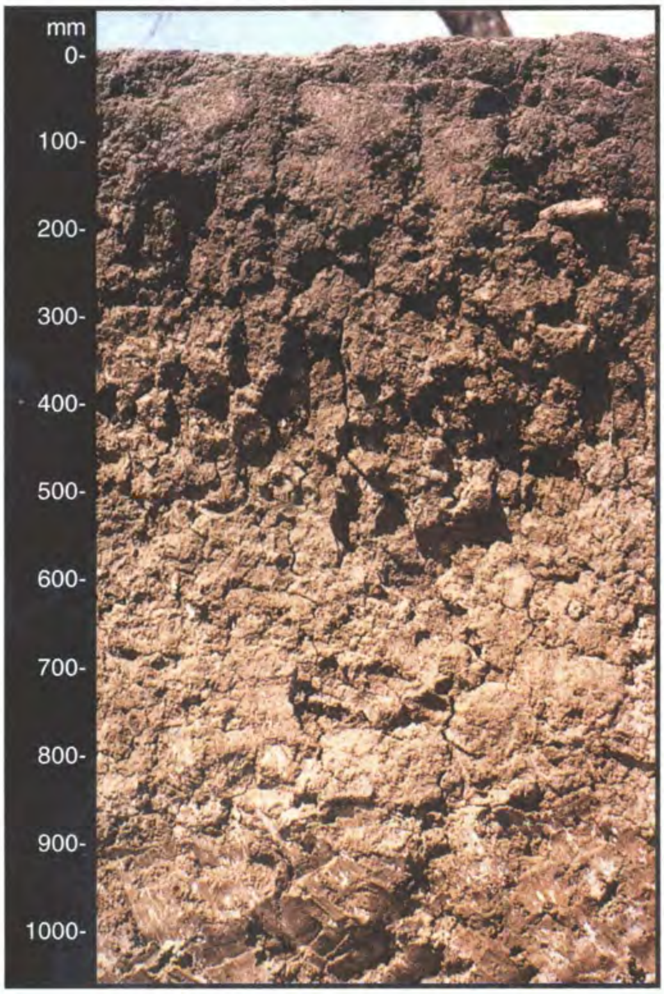
Correlation FAO

Brunic and Chromic Luvisols

Correlation USDA

Alfisols
Aridisols

Valsrivier Form - Va



Orthic A	Dark grey to brown medium sandy loam to sandy clay loam
Pedocutanic B	Blocky yellow-brown or red clay with variegated colours
Unconsolidated material	Partly decomposed sediments

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Colour (subsoil)	Effective rooting depth (mm)
Dry Lowveld	Cretaceous sediments and Alluvium	Valsrivier (calcareous)	Sandy loam	Yellow-brown	400 to 1 000
		Lindley (calcareous)	Sandy clay loam		
		Sheppardvale (calcareous)	Clay		
Coastal Lowlands		Arniston	Sandy clay loam		
		Waterval	Sandy clay loam	Red	

FEATURES TO NOTE

- erodibility : subsoils are often highly erodible with dispersive clays
- irrigation : exceptionally good surface water management and irrigation scheduling are required
- salinity hazard : problems may develop in the Sheppardvale, Valsrivier and Lindley series
- planting : planting on the ridge is recommended
- trashing : under rainfed conditions a good response to a trash blanket can be obtained
- timing : these soils compact when wet and cap when dry, so planting and harvesting should preferably take place in spring or early summer

SELECTED PROPERTIES OF SEPANE FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Katdoorn	35 to 55	100 to 140	Medium to poor	Moderate to poor	Moderate to high	cl, cr, co
Crondale	35 to 55	100 to 140	Medium to poor	Moderate to poor	Moderate to high	cl, cr, co
Ramabesa	35 to 55	100 to 140	Medium to poor	Moderate to poor	Moderate to high	cl, cr, co
Droogpan	35 to 55	100 to 140	Medium to poor	Moderate to poor	Moderate to high	cl, cr, co

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Katdoorn	6,0 to 7,0	Moderate	Absent	Low	Low	Low	Moderate	Moderate	Low to moderate
Crondale	6,0 to 7,0	Moderate	Absent	Low	Low	Low	Moderate	Moderate	Low to moderate
Ramabesa	6,5 to 8,5	Moderate to high	Absent	Moderate	Low	Low	Moderate	Moderate	Moderate to high
Droogpan	6,5 to 8,5	Moderate to high	Absent	Moderate	Low	Low	Moderate	Moderate	Moderate to high

NF - new form in this bulletin

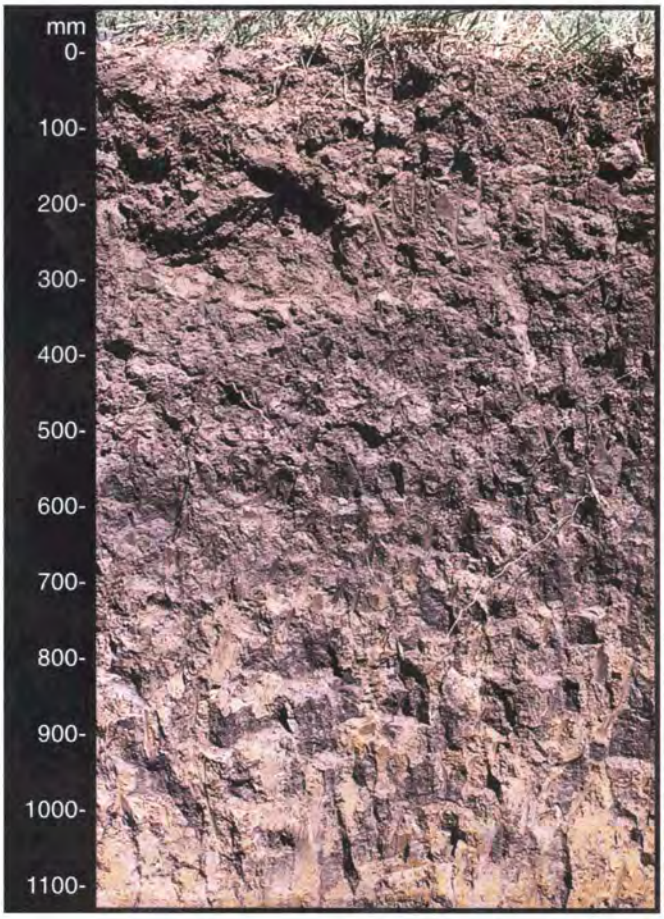
Correlation FAO

Brunic and Chromic Luvisols

Correlation USDA

Alfisols
Aridisols

Sepane Form - Se



Orthic A	Dark grey to brown medium sandy loam to clay loam
Pedocutanic B	Blocky yellow-brown clay with variegated colours
Unconsolidated material with signs of wetness	Partly decomposed sediments with signs of mottling and gleying

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Typical soil families	Main features		Effective rooting depth (mm)
			E horizon	B horizon	
Coastal Lowlands	Alluvium	Katdoorn	Non-bleached	Non-calcareous	400 to 1 000
		Crondale	Bleached	Non-calcareous	
Dry Lowveld	Cretaceous sediments	Ramabesa	Non-bleached	Calcareous	
		Droogpan	Bleached	Calcareous	

FEATURES TO NOTE

- erodibility : subsoils are often highly erodible with dispersive clays
- drainage : may be needed in the Ramabesa and Droogpan families
- irrigation : exceptionally good surface water management and irrigation scheduling are required
- salinity hazard : problems may develop in the Ramabesa and Droogpan families
- planting : planting on the ridge is recommended
- compaction : the bleached Crondale and Droogpan family soils are especially prone to compaction when conditions are wet; harvesting should preferably take place in winter

SELECTED PROPERTIES OF STERKSPRUIT FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Graafwater	0 to 6 (medium sand)	Less than 80	Very low	Poor	Very high	cr, co, mw, sh
Hartbees	6 to 15 (medium sand)	80 to 100	Low	Poor	Very high	cr, co, sh
Sterkspruit	15 to 35 (undifferentiated)	Less than 80	Low	Very poor	Very high	cl, cr, co, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Graafwater	6,0 to 9,0	Low	Absent	Low	Low	Low	Low	Low	High
Hartbees	6,0 to 9,0	Low to moderate	Absent	Low	Low	Low	Low	Low	High
Sterkspruit	6,0 to 9,0	Moderate to high	Absent	Low	Low	Low	Low	Low	High

Correlation FAO

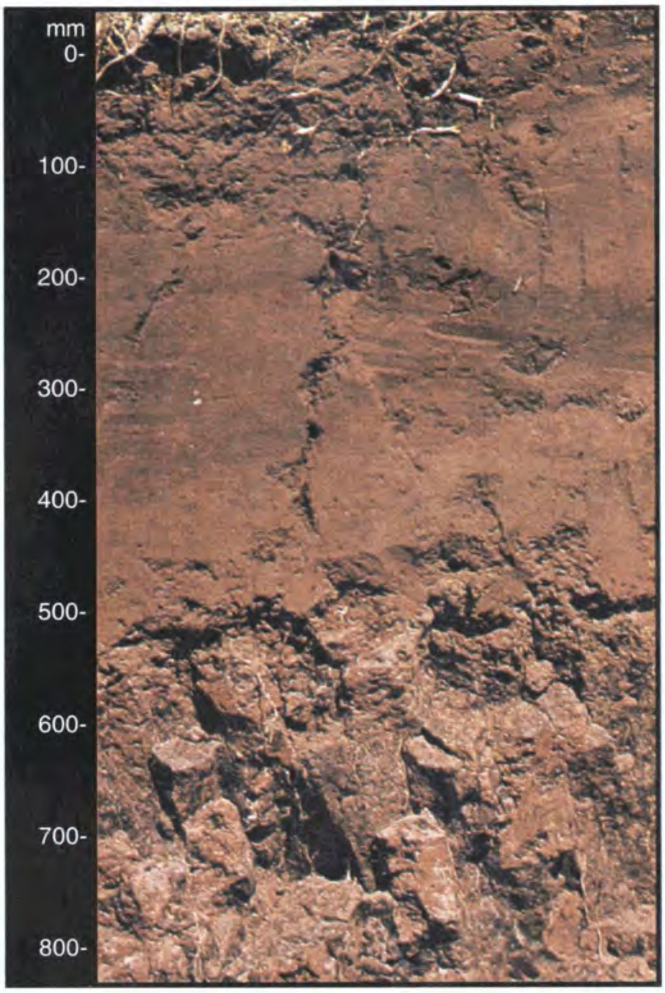
Ochric Solonetz

Correlation USDA

Alfisols
Aridisols

Sterkspruit Form - Ss

Orthic A	Grey to brown sand to sandy loam
Prismacutanic B	Slowly permeable, olive-brown prismatic clay with lime concretions



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Dry Lowveld River Valley	Granite	Graafwater	Medium sand	300 to 600
	Vryheid sediments	Hartbees	Medium loamy sand	
	Dwyka tillite	Sterkspruit	Fine sandy loam	

FEATURES TO NOTE

- non-arable : when effective rooting depth is less than 400 mm
- erodibility : the easily dispersed topsoil is highly erodible so lands should be well protected and minimum tillage practised once fields have been levelled and drained
- poorly drained : installation of drains is often essential to avoid wetness and salinity development
- irrigation problems : a low available water capacity, shallow depth, low intake rate and poor drainage make good irrigation control and short cycles essential
- land smoothing : surface water management is very important
- winter harvest : infield traffic will compact and damage the soil when wet, so plan to harvest in winter
- nematodes : nematicides may be effective in the sandy Graafwater series
- planting : planting on the ridge has given good results
- fertiliser : split applications of N and K recommended

SELECTED PROPERTIES OF SHORTLANDS FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Argent	35 to 55	100 to 180	Medium	Good	Very low	cl
Glendale	35 to 55	100 to 180	Medium	Good	Very low	cl
Sunvalley	35 to 55	100 to 180	Medium	Good to moderate	Very low	cl
Shortlands	More than 55	140 to 180	Medium	Good	Very low	cl

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Argent	5,0 to 6,0	Moderate	Absent	Moderate	High	Moderate to high	Moderate	Moderate to high	Low
Glendale	6,0 to 7,0	High	Absent	Low to moderate	High	Moderate to high	Moderate to high	Moderate to high	Low
Sunvalley	7,0 to 8,5	Very high	Absent	Low to moderate	High	Moderate to high	Moderate to high	Moderate	Moderate
Shortlands	6,0 to 7,0	High	Absent	Low to moderate	High	Moderate to high	Moderate to high	Moderate to high	Low

*Free lime present

Correlation FAO

Chromic, Ferric and Rhodic Luvisols

Correlation USDA

Alfisols

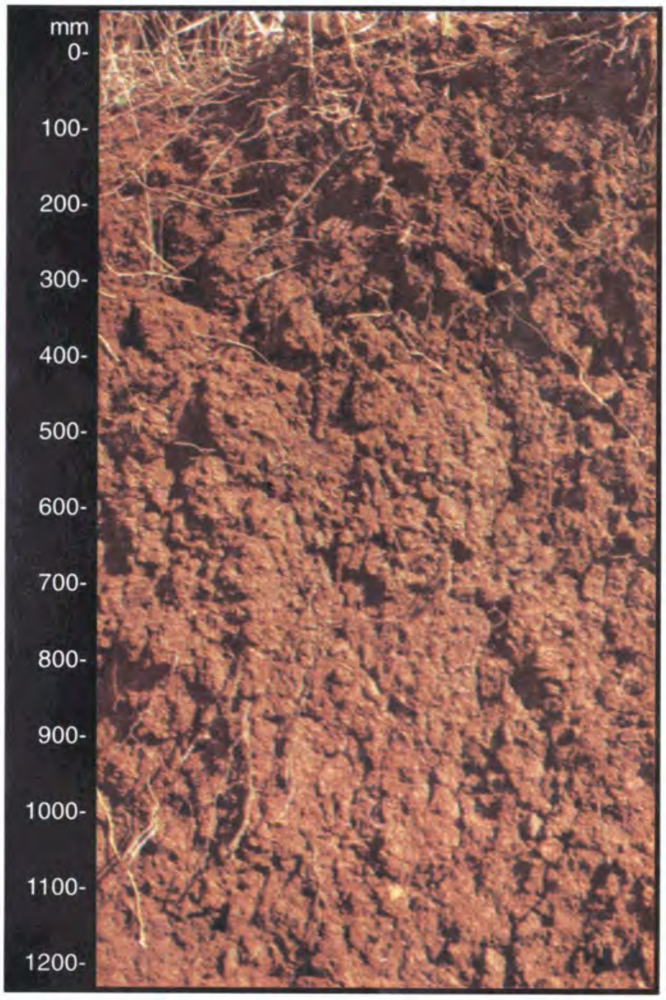
FEATURES TO NOTE

- physical properties : good; these soils have high potential
- soil tilth : Shortlands series should not be worked when too wet or dry; these soils should be planted in early spring
- nutrient status : well supplied with calcium and magnesium; mineralise considerable quantities of nitrogen with no leaching or denitrification problems, so applied nitrogen levels may be below average; higher than average potassium for winter cycle cane may be required on the high clay soils in the Dry Lowveld; phosphorus fixation may be a problem in the Argent, Shortlands and Sunvalley series
- salinity hazard : low quality irrigation water may cause saline conditions along drainage lines only in the Sunvalley series
- trashing : a good response to a trash blanket can be expected
- drying off : is difficult because of the high TAW; allow 7-8 weeks in winter on deep soils

Shortlands Form - Sd

Orthic A

Red structured B



Dark reddish-brown clay loam to clay

Reddish-brown blocky clay

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands Dry Lowveld	Tugela schist Dolerite-basalt	Glendale	Clay loam	900 to 1 200
		Shortlands	Clay	
Humid Lowveld	Swaziland basic rocks	Argent	Sandy clay loam	
Dry Lowveld	Swaziland basic rocks Alluvium	Glendale	Clay loam	
	Swaziland basic rocks Dolerite-basalt	Sunvalley (calcareous)	Clay loam	

SELECTED PROPERTIES OF HUTTON FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Joubertina	0 to 6 (medium sand)	Less than 80	Good	Excessive	Severe	cr, co, mw
Clansthal	6 to 15 (medium sand)	100 to 140	Good	Excessive	Moderate to severe	cr, mw
Shorrocks	15 to 35	100 to 180	Good	Good	Low to moderate	cr, mw
Msinga	15 to 35	100 to 180	Good	Good	Low to moderate	cr
Makatini	35 to 55	140 to 180	Medium to good	Good	Low	cr
Doveton	35 to 55	140 to 180	Medium to good	Good	Low	none
Farningham	35 to 55	140 to 180	Medium to good	Good	Low	none
Balmoral	More than 55	More than 180	Medium	Good	Very low	cl
Vimy	More than 55	More than 180	Medium	Good	Very low	cl

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Joubertina	5,0 to 8,5*	Low	Low	Low	Low	Low	Low	Low	Low
Clansthal	5,0 to 8,5*	Low	Low	Low	Moderate	Moderate	Low	Low	Low
Shorrocks	6,0 to 8,0	Moderate to high	Absent	Low to moderate	Moderate	Moderate	Moderate	Low to moderate	Low
Msinga	5,0 to 6,5	Moderate	Low	Low to moderate	Moderate	Moderate	Moderate	Low to moderate	Low
Makatini	6,0 to 7,0	High	Absent	Low to moderate	Moderate	Moderate	Moderate to high	Moderate	Low
Doveton	5,0 to 6,0	Moderate	Moderate	Moderate to high	High	High	Moderate	Moderate	Absent
Farningham	4,5 to 5,5	Low to moderate	Moderate to high	Moderate to high	High	High	Low to moderate	Low	Absent
Balmoral	4,5 to 5,5	Low to moderate	Moderate to high	Moderate to high	High	High	Low to moderate	Low	Absent
Vimy	6,0 to 7,0	Moderate to high	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Low

*pH values in excess of 7,5 generally indicate the previous use of filtercake containing lime

Correlation FAO

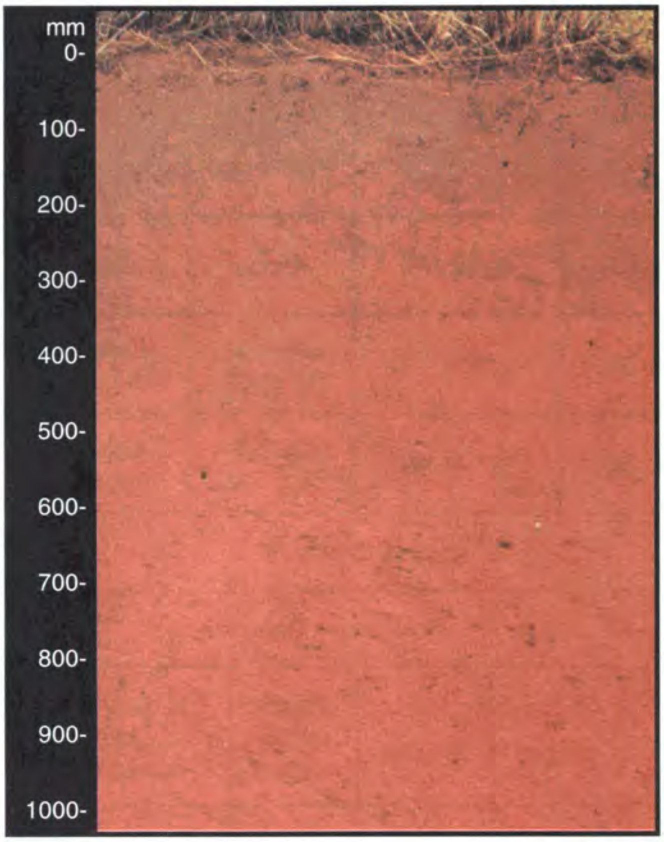
Primarily Rhodic and Helvic Ferralsols

Correlation USDA

Oxisols
Ultisols

Hutton Form - Hu

Orthic A	Dark reddish-brown loamy sand to clay
Red apedal B	Reddish-brown loamy sand to porous non-blocky clay



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Joubertina	Medium sand	More than 1 200
		Clansthal	Medium loamy sand	
Dry Lowveld	Alluvium Granite (granodiorite)	Shorrocks	Sandy loam	800 to 1 200
Dry Lowveld River Valley	Alluvium Swaziland basic rocks	Makatini	Sandy clay loam	More than 1 200
Humid Lowveld	Alluvium Granite (granodiorite) Swaziland basic rocks	Msinga	Sandy loam	500 to 700
Hinterland	Tugela schist	Doveton	Clay loam to clay	700 to 1 000
	Dolerite	Vimy	Clay	
	Natal Group Sandstone	Msinga	Sandy loam	
Mistbelt	Natal Group Sandstone Vryheid sediments	Farningham	Clay loam	700 to 1 200
	Dolerite	Balmoral	Clay	

FEATURES TO NOTE

- field layout : good conservation layouts are important on the erodible Joubertina and Clansthal series; strip cropping and a trash blanket are good conservation measures
- minimum tillage : essential on the erodible Clansthal and Joubertina series
- agricultural limestone and gypsum : commonly required on the highly weathered Farningham and Balmoral series and occasionally on the Joubertina and Clansthal series
- phosphorus fixation : the Farningham and Balmoral series are commonly high phosphorus fixing
- nitrogen and sulphur : requirements below average due to a favourable N mineralisation potential in most soils

SELECTED PROPERTIES OF BLOEMDAL FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Roodeplaat	5 to 20	80 to 100	Good	Good	Low	cr, co, mw
Wilton	10 to 35	100 to 140	Medium to good	Moderate to good	Low to moderate	cl, cr, co
Waldo	10 to 35	100 to 140	Medium to good	Moderate to good	Low to moderate	cl, cr, co

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Roodeplaat	6,5 to 8,5	Moderate to high	Absent	Low	Moderate	Medium	Moderate	Moderate	Moderate
Wilton	4,5 to 5,5	Very low	Low to moderate	Moderate	Moderate	Medium	Low	Low	Absent
Waldo	5,5 to 7,5	Low to moderate	Absent	Low to moderate	Moderate	Medium	Low to moderate	Moderate	Low

NF - new form in this bulletin

Correlation FAO

Rhodic and Helvic Ferralsols

Correlation USDA

Oxisols
Ultisols

Bloemdal Form - Bd

Orthic A	Dark reddish-brown loamy sand to clay
Red apedal B	Reddish-brown loamy sand to porous non-blocky clay
Unspecified material with signs of wetness	Signs of mottling and yellow staining

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families*	Main features	Effective rooting depth (mm)
Coastal Sands (low lying) Hinterland Mistbelt	Recent Sands Dwyka tillite Dolerite Pietermaritzburg shales Vryheid sediments	Wilton	Dystrophic	More than 800
		Waldo	Mesotrophic	
Dry Lowveld	Alluvium Granite	Roodeplaat	Eutrophic	

*With luvic B horizons

FEATURES TO NOTE

- field layout : good conservation layouts are important on the Recent Sands; strip cropping, narrow row spacing and a trash blanket are good conservation measures
- minimum tillage : is essential on erodible sandy soils and shallow ploughing on the remainder
- productivity : often outyields similar Hutton form soils because of seepage water from higher up the slope
- agricultural limestone and gypsum : commonly required on the highly weathered Wilton family soils

SELECTED PROPERTIES OF BAINSVLEI FORM SOIL SERIES (NF)

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Vungama	0 to 6	Less than 80	Very high	Excessive	Very high	mw, sh
Redhill	5 to 15	80 to 100	High	Good	High	cr, co, mw, sh
Elysium	15 to 35	100 to 140	High to medium	Good to moderate	Moderate	cl, cr, co, mw, sh
Lonetree	15 to 35	100 to 140	High to medium	Good to moderate	Moderate	cl, co, cr, mw, sh
Bainsvlei	15 to 35	100 to 140	High to medium	Good to moderate	Moderate	cl, cr, co, mw, sh
Metz	More than 35	100 to 140	Medium	Moderate	Low	cl, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Vungama	5,0 to 6,0	Low	Low	Low	Low	Low	Low	Low	Absent
Redhill	6,0 to 7,0	Low to moderate	Absent	Low	Low	Low	Low	Low	Absent
Elysium	5,0 to 6,0	Low	Moderate	Low to moderate	Low to moderate	Low to moderate	Moderate	Moderate	Low
Lonetree	6,0 to 7,0	Moderate	Absent	Low to moderate	Moderate	Moderate	Moderate	Moderate	Low
Bainsvlei	6,5 to 8,5	High	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Metz	6,0 to 7,0	High	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Low

NF - new form in this bulletin

Correlation FAO

Plinthic Ferralsols

Correlation USDA

Oxisols
Alfisols

FEATURES TO NOTE

- low nutrient status : Vungama and Redhill series commonly require agricultural lime due to calcium or magnesium deficiency or aluminium toxicity; phosphorus fixation may be a problem in the Bainsvlei series, potassium is inherently low and nitrogen mineralisation moderate
- erodibility : the Vungama and Redhill series need protection with careful field layouts and limited cultivation
- drainage : despite the soft plinthite, the depth of A and B horizons is generally good and drainage is unlikely to be a problem in the Bainsvlei series, but it could be a problem in the Metz series
- irrigation : good irrigation control is required in the Metz series
- productivity : often outyields similar Hutton form soils because of seepage water from higher up the slope

Bainsvlei Form - Bv

Orthic A	Dark grey-brown sand to sandy loam
Red apedal B	Reddish-brown porous non-blocky clay
Soft plinthic B	Soft iron concretions

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands Hinterland Mistbelt	Natal Group Sandstone	Vungama	Medium sand	600 to 800
	Vryheid sediments Natal Group Sandstone	Redhill	Loamy sand	
		Elysium	Sandy loam to sandy clay loam	
	Dwyka tillite	Lonetree	Sandy loam to sandy clay loam	
	Dolerite Basalt Pietermaritzburg shales Tarkastad sediments	Metz	Sandy clay	
Lowveld	Basalt	Bainsvlei	Sandy loam to sandy clay loam	

SELECTED PROPERTIES OF AUGRABIES FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Hefnaar	Less than 15	Less than 80	Good	Good	Very high	co, mw
Giyani	Less than 15	Less than 80	Good	Good	Very high	co, mw
Khubus	More than 15	80 to 100	Moderate to good	Good	High	co, mw
Shilowa	More than 15	80 to 100	Moderate to good	Good	High	co, mw

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Hefnaar	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Low	Low	Low	Low	Low to moderate
Giyani	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Low	Low	Low	Low	Low to moderate
Khubus	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Low	Low	Low	Low	Low to moderate
Shilowa	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Low	Low	Low	Low	Low to moderate

NF - new form in this bulletin

Correlation FAO

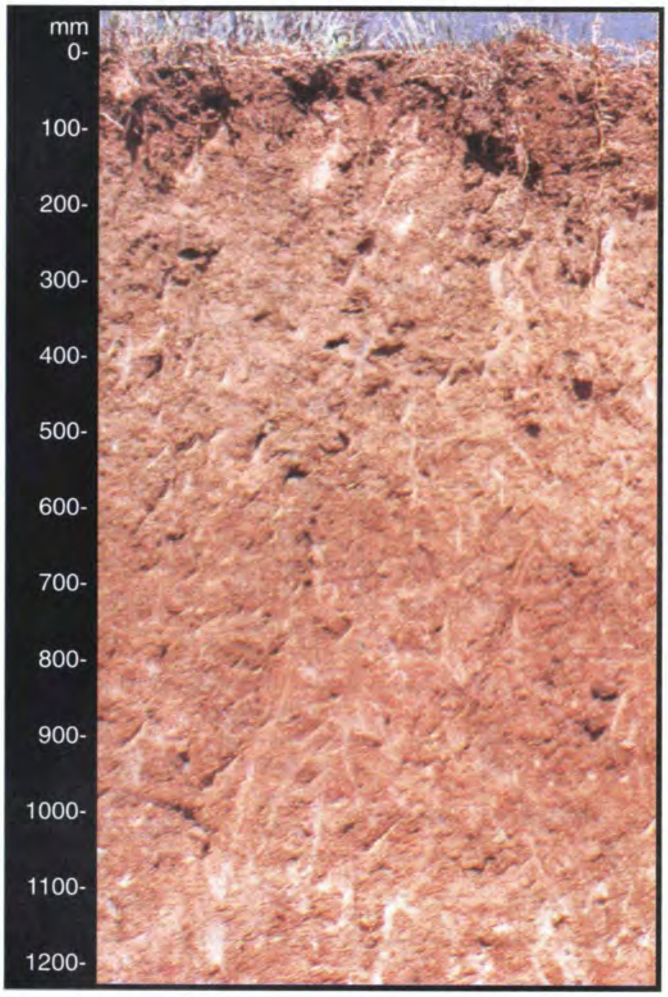
Calcisols

Correlation USDA

Aridisols (with Calcic B horizon)

Augrabies Form - Ag

Orthic A	Reddish-brown sandy loam
Neocarbonate B	Pale brown weakly structured loam speckled with white lime concretions
Unspecified	Non-diagnostic



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Colour of B horizon	Soil texture	Effective rooting depth (mm)
Dry Lowveld	Alluvium Granite	Hefnaar	Non-red	Non-luvic B1 horizon	700 to more than 1 000
		Giyani		Luvic B1 horizon	
		Khubus	Red	Non-luvic B1 horizon	
		Shilowa		Luvic B1 horizon	

FEATURES TO NOTE

- erodibility : the easily dispersed topsoil is highly erodible, so fields should be well protected; use minimum tillage and protect with trash or scattered tops
- irrigation : exceptionally good surface water management and irrigation scheduling are required
- salinity hazard : in low lying areas there is a high risk of salinity developing
- crusting : under centre pivot irrigation crusting and slaking may occur
- potassium : due to a high calcium and magnesium to potassium ratio, above average potash will be needed for cane growing on a winter cycle

SELECTED PROPERTIES OF CLOVELLY FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Sandspruit	0 to 6 (medium sand)	Less than 80	Good	Excessive	High	co, mw
Denhere	6 to 15 (coarse sand)	Less than 80	Good	Excessive	High	cr, co, mw
Springfield	6 to 15 (medium sand)	80 to 100	Good	Excessive	High	cr, co, mw
Oatsdale	15 to 35 (undifferentiated)	100 to 140	Good	Good	Moderate to low	cr, co
Clovelly	35 to 55 (undifferentiated)	100 to 180	Good to medium	Good	Low	cr
Balgowan	More than 55 (undifferentiated)	140 to 180	Good to medium	Good	Low	cr

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Sandspruit	6,0 to 7,0	Moderate to low	Absent	Low	Low	Low	Low	Moderate	Low
Denhere	6,0 to 7,0	Moderate	Absent	Low	Low	Low	Low	Moderate	Low
Springfield	5,5 to 7,0	Moderate to low	Low	Low	Low	Low	Low	Moderate	Low
Oatsdale	4,0 to 6,0	Low	Moderate	Moderate	Moderate	Moderate	Low	Low	Absent
Clovelly	4,0 to 6,0	Low	Severe	High	Moderate to high	Moderate to high	Low	Low	Absent
Balgowan	4,0 to 6,0	Low	Severe	Very high	Moderate to high	Moderate to high	Low	Low	Absent

Correlation FAO

Helvic and Ochric Ferralsols

Correlation USDA

Oxisols

FEATURES TO NOTE

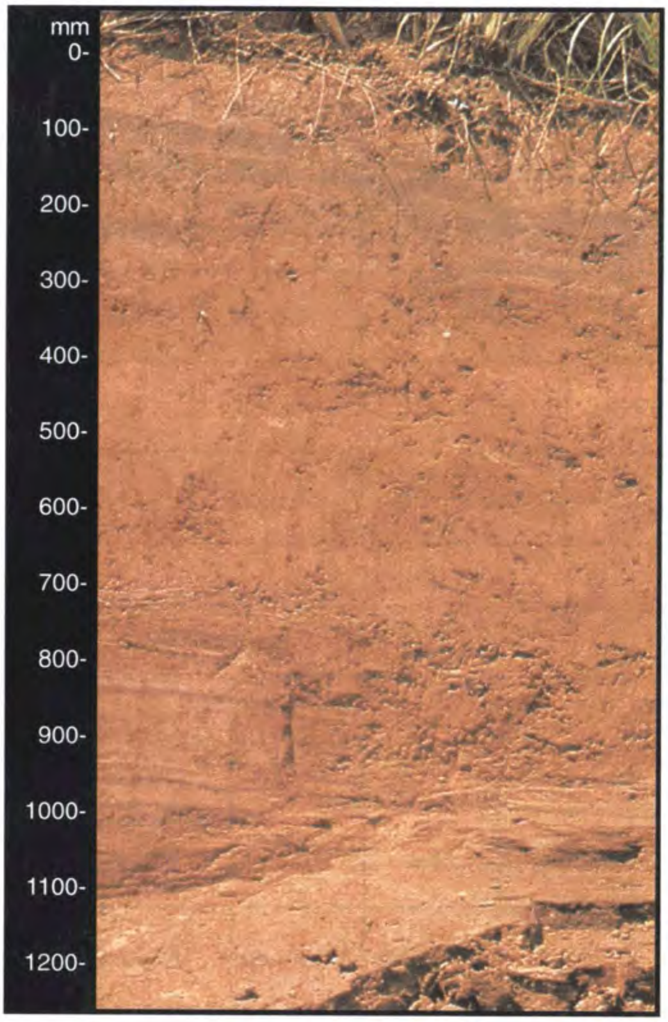
- conservation : good layouts are important in the Sandspruit, Denhere and Springfield series; other measures include strip cropping and a trash blanket
- minimum tillage : is essential on the erodible sandy soils of the Sandspruit, Denhere and Springfield series
- low nutrient status : lime, gypsum, phosphorus, potassium and zinc requirements likely to be high in soils of the Mistbelt system; comprehensive soil sampling is essential
- nitrogen and sulphur : requirement should be below average for cane growing in Mistbelt soils
- acid chlorosis : iron deficiency symptoms induced by manganese toxicity may occur under cool, moist, cloudy conditions in spring
- nematodes : may be a problem in the Sandspruit and Denhere series
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils of the Mistbelt

Clovelly Form - Cv

Orthic A

Yellow-brown apedal B

C or rock



Dark greyish-brown sand to clay

Yellow-brown sand to friable non-structured clay

Non-diagnostic weathering rock

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Sandspruit	Medium sand	More than 1 000
		Denhere	Coarse loamy sand	
Hinterland	Alluvium	Springfield	Medium loamy sand	
Mistbelt	Natal Group Sandstone Vryheid sediments Dwyka tillite	Oatsdale	Sandy loam	600 to 900
	Dwyka tillite	Clovelly	Sandy clay loam	
	Pietermaritzburg shales Vryheid sediments	Balgowan	Clay	600 to 1 200

SELECTED PROPERTIES OF GRIFFIN FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Burnside	6 to 15	80 to 100	Good	Very good	High	co, mw
Cleveland	15 to 35	100 to 140	Good	Good	Moderate to low	cr, co, mw
Griffin	35 to 55	100 to 180	Medium	Good	Low	cr, co
Farmhill	More than 55	140 to 180	Medium	Good	Low	cr, co

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Burnside	4,0 to 6,0	Low	Moderate	Low	Low	Low	Low	Moderate	Absent
Cleveland	4,0 to 6,0	Low	High	Moderate	Moderate	Moderate	Low	Low	Absent
Griffin	4,0 to 6,0	Low	High	High	High	Moderate to high	Low	Low	Absent
Farmhill	4,0 to 6,0	Low	High	Very high	High	Moderate to high	Low	Low	Absent

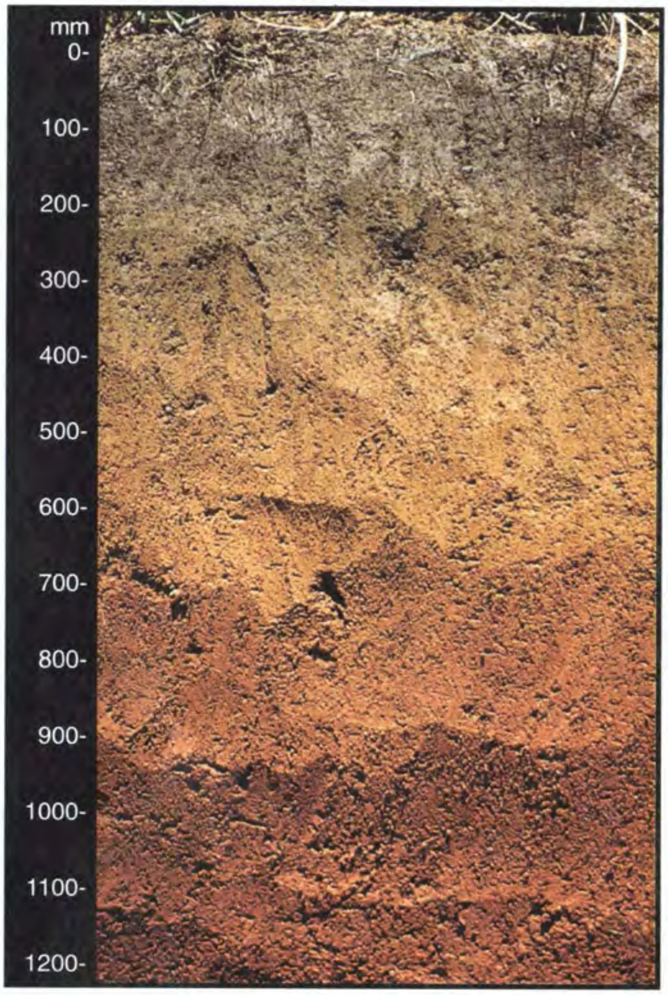
Correlation FAO

Helvic Acrisols
Helvic Ferralsols

Correlation USDA

Ultisols
Oxisols

Griffin Form - Gf



Orthic A	Dark grey to brown loamy sand to clay
Yellow-brown apedal B	Yellow-brown loamy sand to friable clay
Red apedal B	Red loamy sand to friable non-structured clay

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Mistbelt	Natal Group Sandstone	Burnside	Loamy sand to sandy loam	700 to 1 000
	Natal Group Sandstone Dwyka tillite	Cleveland	Sandy loam to sandy clay loam	
	Dwyka tillite	Griffin	Clay loam	
	Pietermaritzburg shales Vryheid sediments	Farmhill	Clay	

FEATURES TO NOTE

- physical properties : good
- lime and gypsum : use generally widespread because of aluminium toxicity and low calcium and magnesium status in top and subsoils
- phosphorus requirement : generally high because of phosphorus fixation
- potassium availability : may be a problem so soil and leaf sampling required
- zinc : zinc at planting is advisable
- nitrogen and sulphur : requirements are lower than normal in the Griffin and Farmhill series
- acid chlorosis : iron deficiency symptoms induced by manganese toxicity may occur under cool, moist, cloudy conditions in spring
- filtercake and poultry manure : good growth responses have been obtained in P deficient soils of the Mistbelt

SELECTED PROPERTIES OF AVALON FORM SOIL SERIES

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Kanhym	6 to 15 (medium sand)	80 to 100	Medium	Moderate	High	co, mw
Ruston	15 to 35 (undifferentiated)	100 to 140	Medium	Moderate	Moderate	cr, co, mw
Bezuidenhout	More than 35 (undifferentiated)	100 to 180	Medium to poor	Moderate to poor	Low	cr

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Kanhym	4,5 to 6,0	Very low	Moderate	Moderate	Low	Low to moderate	Low	Low	Absent
Ruston	4,5 to 6,0	Low	Moderate	Moderate to high	Low	Moderate	Low	Low	Absent
Bezuidenhout	6,0 to 7,0	High	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate to high

Correlation FAO

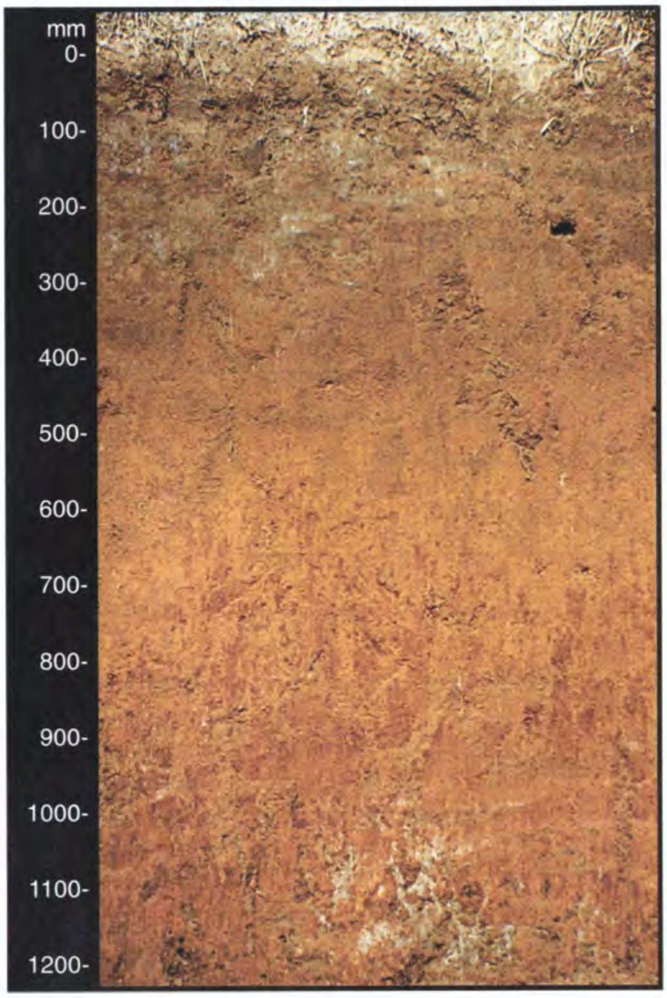
Plinthic Luvisols, Ferralsols and Acrisols

Correlation USDA

Alfisols
Ultisols

Avalon Form - Av

Orthic A		Dark grey-brown sandy loam to clay loam
Yellow-brown apedal B		Yellow-brown friable loamy sand to non-structured clay
Soft plinthic B		Soft iron concretions



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Hinterland	Natal Group Sandstone	Kanhym	Medium sandy loam	600 to 800
Mistbelt		Ruston	Sandy clay loam	800 to 1 000
Dry Lowveld	Vryheid sediments Dwyka tillite	Bezuidenhout	Clay loam	600 to 800

FEATURES TO NOTE

- low nutrient status : Kanhym and Ruston series commonly require agricultural lime due to calcium or magnesium deficiency or aluminium toxicity; phosphorus fixation may be a problem potassium is inherently low and nitrogen mineralisation is low to moderate
- minimum tillage : is essential on the erodible Kanhym series soil
- drainage : despite the soft plinthite, the depth of A and B horizons is generally good and drainage is unlikely to be a problem in the Kanhym and Ruston series, but it could be a problem in the Bezuidenhout series
- irrigation : good irrigation control is required in the Bezuidenhout series
- productivity : often outyields similar Clovelly form soils because of seepage water from higher up the slope

SELECTED PROPERTIES OF GLENCOE FORM SOIL SERIES (NF)

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Penhoek	0 to 6	Less than 80	High	Moderate	High	mw, sh
Dunbar	6 to 15	80 to 100	High	Moderate	High	cr, co, mw, sh
Glencoe	15 to 35	100 to 140	Medium	Moderate to poor	Moderate	cl, cr, co, mw, sh
Ontevrede	More than 35	100 to 140	Low	Moderate to poor	Low	cl, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Penhoek	5,0 to 6,0	Low	Low	Moderate	Low	Low to moderate	Low	Low	Absent
Dunbar	5,0 to 6,0	Moderate	Low	Moderate to high	Low	Moderate	Low	Low	Absent
Glencoe	6,0 to 7,0	High	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Low
Ontevrede	6,0 to 7,0	High	Absent	Moderate	Moderate	Moderate	Moderate	Moderate	Low

NF - new form in this bulletin

Correlation FAO

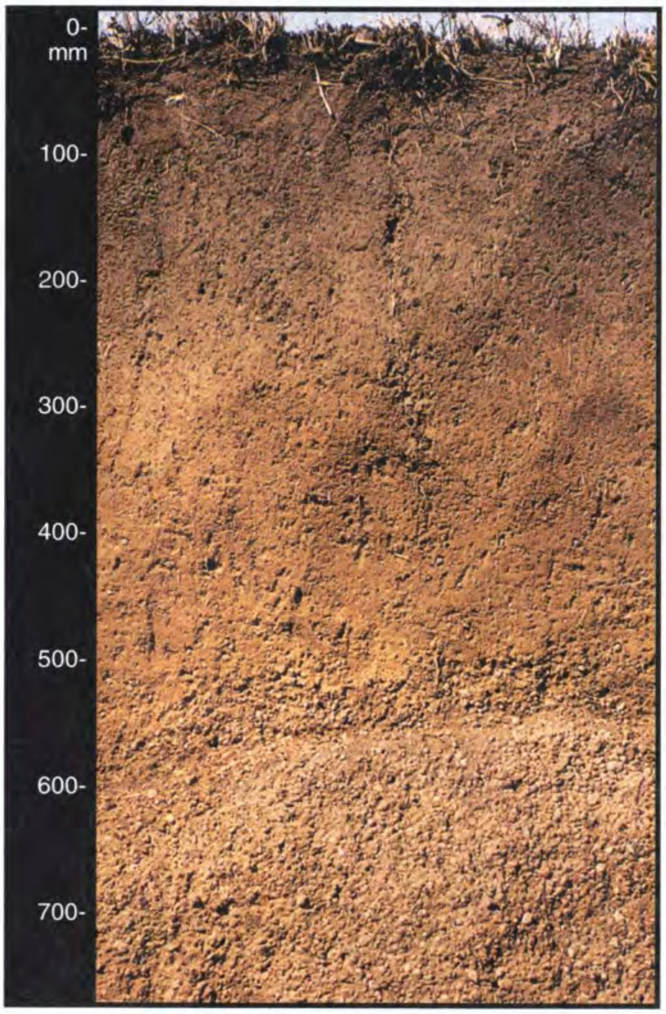
Ochric and Eutric Cambisols (concretionary phase)

Correlation USDA

Oxisols

Glencoe Form - Gc

Orthic A	Dark grey-brown sand to sandy loam
Yellow-brown apedal B	Yellow-brown friable loamy sand to non-structured clay
Hard plinthic B	Impermeable hard plinthic layer



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Sands Hinterland	Natal Group Sandstone	Penhoek	Medium sand	400 to 800
		Dunbar	Medium loamy sand	
	Dwyka tillite Vryheid sediments	Glencoe	Sandy loam to sandy clay loam	
		Ontevrede	Fine sandy clay	

FEATURES TO NOTE

- non-arable : if less than 400 mm deep
- low nutrient status : potassium is inherently low and nitrogen mineralisation is low to moderate
- erodibility : the Penhoek and Dunbar series need protection with careful field layouts and limited cultivation
- drainage : despite the hard plinthite, the depth of A and B horizons is generally fair, but it could be a problem in the Ontevrede series
- irrigation : good irrigation control is required

SELECTED PROPERTIES OF PINEDENE FORM SOIL SERIES (NF)

Soil series	Physical					
	Clay % B horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Pinedene	6 to 15	80 to 100	High	Moderate	High	cr, co, mw
Tulbagh	6 to 15	80 to 100	High	Moderate	High	cr, co, mw
Ouwerf	15 to 35	100 to 140	Medium	Moderate to poor	Moderate	cl, cr, co, mw
Suurbraak	15 to 35	100 to 140	Medium	Moderate to poor	Moderate	cl, cr, co, mw
Klerksdorp	15 to 35	100 to 140	Medium	Moderate to poor	Moderate	cl, cr, co, mw
Kilburn	More than 35	100 to 140	Low	Poor	Low	cl, mw

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Pinedene	5,0 to 7,5	Low	Low	Low	Low to moderate	Low	Low	Low	Low
Tulbagh	6,0 to 7,5	Low to moderate	Absent	Low	Low to moderate	Low to moderate	Low	Low	Low
Ouwerf	5,0 to 7,5	Low to moderate	Low	Moderate	Low to moderate	Low to moderate	Low	Low	Absent
Suurbraak	6,0 to 7,5	Low to moderate	Absent	Moderate	Moderate	Moderate	Low	Low	Low
Klerksdorp	6,0 to 7,5	Moderate	Absent	Low	Moderate	Moderate	Moderate	Moderate	Low
Kilburn	5,0 to 6,5	Low to moderate	Moderate	Moderate to high	Moderate to high	Moderate to high	Low	Low	Absent

NF - new form in this bulletin

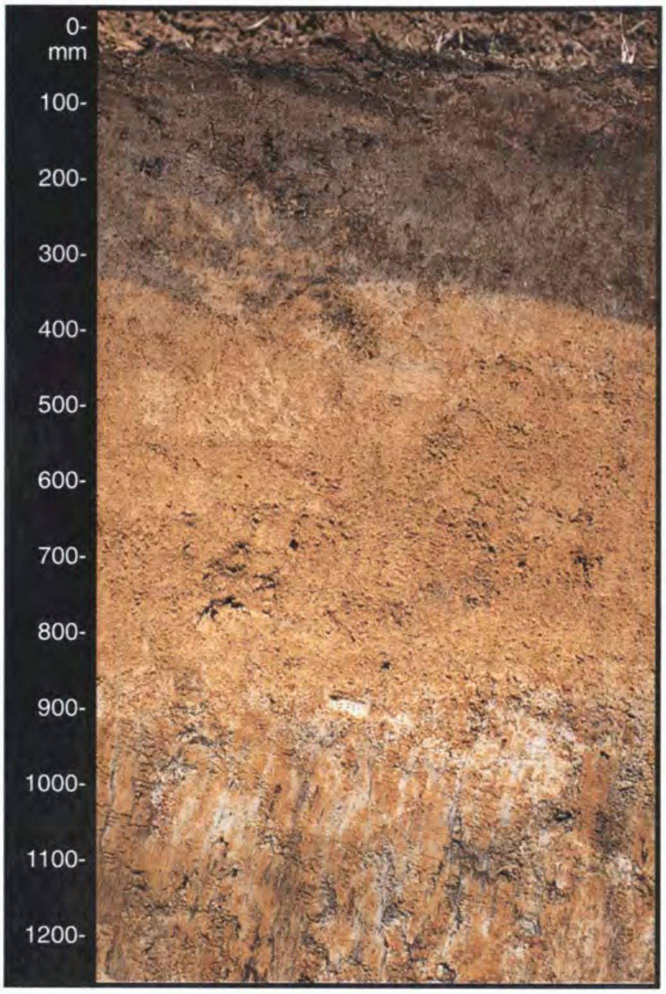
Correlation FAO

Gleyic Luvisols
Gleyic Acrisols

Correlation USDA

Ultisols
Alfisols

Pinedene Form - Pn



Orthic A	Grey to dark medium loamy sand to sandy clay loam
Yellow-brown apedal B	Yellow-brown sand to friable non-structured clay loam
Unspecified material with signs of wetness	Deep grey mottled yellow heavy clay (gley)

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems except Dry Lowveld	Natal Group Sandstone Vryheid sediments Granite Dwyka tillite	Pinedene	Medium loamy sand	600 to 1 200
		Tulbagh	Medium loamy sand	
		Ouwerf	Sandy loam to sandy clay loam	
		Suurbraak	Sandy loam to sandy clay loam	
		Kilburn	Sandy clay	
Dry Lowveld	Vryheid sediments Basalt	Klerksdorp	Sandy loam to sandy clay loam	500 to 800

FEATURES TO NOTE

- high erodibility : good soil protection measures essential, especially when sandy topsoil occurs
- drainage : in low lying or valley bottom areas subsurface drainage may be necessary
- timing : all operations should preferably be carried out in the dry winter period
- low nutrient status : higher than normal amounts of nutrients are required, particularly N and K, which are likely to be lost because of wetness

SELECTED PROPERTIES OF KATSPRUIT FORM SOIL SERIES

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Katspruit	6 to 15	100 to 180	Poor	Very poor	Moderate	cl, cr, co, sh
Killarney	6 to 15	100 to 180	Poor	Very poor	Moderate	cl, cr, co, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Katspruit	5,0 to 7,0	Low to moderate	Absent	Low	Moderate to low	Low	Low	Low	Moderate
Killarney	7,0 to 9,0	High*	Absent	Low	Moderate to low	Low	Low	Low	High

*Free lime present

Correlation FAO

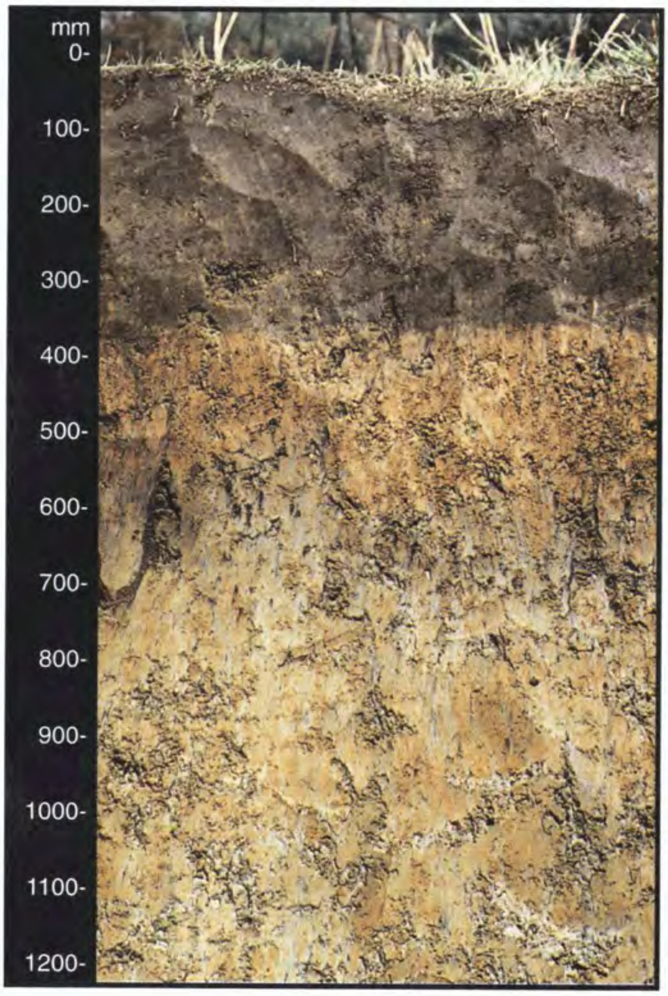
Gleysols

Correlation USDA

Inceptisols
Entisols

Katspruit Form - Ka

Orthic A	Grey to dark medium loamy sand to sandy loam
G horizon	Deep mottled gley with a water table



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems except Dry Lowveld	Natal Group Sandstone Vryheid sediments Alluvium	Katspruit	Loamy sand to sandy loam	300 to 500
Dry Lowveld	Granite Dwyka tillite Vryheid sediments	Killarney (calcareous)	Loamy sand to sandy loam	

FEATURES TO NOTE

non-arable : if less than 400 mm and all wetland

poorly drained : subsurface pipe and mole drains are invariably required in this valley bottom soil, particularly in the Killarney series where there is a salinity hazard

irrigation : generally not recommended, but where practised good irrigation scheduling is essential

land smoothing : surface water management must be good as intake rate and drainage are poor

planting : planting on the ridge is recommended

timing : all operations should be carried out in the dry winter period; minimum tillage is recommended

low nutrient status : higher than normal amounts of nutrients are required, particularly nitrogen and potassium, which are likely to be lost because of wetness; split applications of fertiliser are recommended; frequent leaf sampling is essential

burn at harvest : a trash blanket will aggravate the wetness problem

SELECTED PROPERTIES OF KROONSTAD FORM SOIL SERIES

Soil series	Physical					
	Clay % E horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Kroonstad	6 to 15 (fine sand)	Less than 80	Medium	Poor	Very high	cr, co, sh
Mkambati	6 to 15 (medium sand)	80 to 100	Medium	Poor	Very high	cr, co, sh
Katarra	0 to 6 (coarse sand)	Less than 80	Medium	Poor	Very high	co, mw, sh
Avoca	15 to 35 (medium sand)	100 to 140	Medium to poor	Poor	Very high	cl, cr, co, sh
Bluebank	15 to 35 (fine sand)	100 to 140	Poor	Poor	Very high	cl, cr, co, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Kroonstad	5,5 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low to moderate
Mkambati	5,5 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low to moderate
Katarra	6,0 to 8,0	Low	Absent	Low	Low	Low	Low	Low	Moderate
Avoca	5,5 to 7,0	Moderate	Absent	Low	Low	Low	Low	Moderate	Moderate
Bluebank	5,5 to 7,0	Moderate	Absent	Low	Low	Low	Low	Moderate	Moderate

Correlation FAO

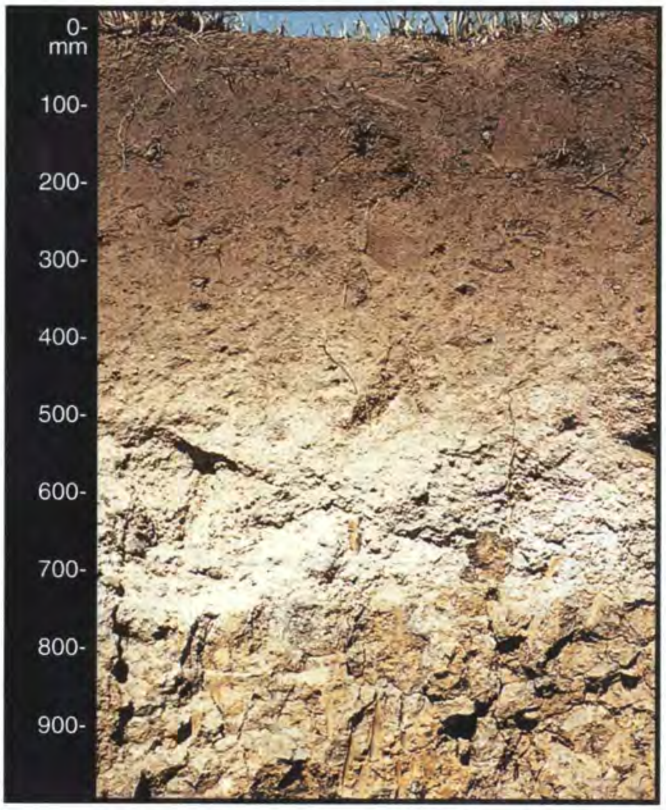
Ochric Planosols

Correlation USDA

Alfisols

Kroonstad Form - Kd

Orthic A	Grey sand to sandy clay loam
E horizon	Bleached grey or white
G horizon	Wet gleyed mottled clay



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Kroonstad	Fine sand	450 to 1 200
Coastal Lowlands	Natal Group Sandstone	Mkambati	Medium sand	600 to 800
Dry Lowveld Humid Lowveld Coastal Lowlands	Granite	Katarra	Coarse sand	400 to 600
	Vryheid sediments Alluvium	Avoca	Medium sandy loam	600 to 800
Coastal Lowlands	Dwyka tillite Vryheid sediments	Bluebank	Fine sandy clay loam	400 to 600

FEATURES TO NOTE

- non-arable : when less than 400 mm deep and if part of a wetland
- high erodibility : use minimum tillage; protect with a trash blanket or leave burnt tops scattered; do not cultivate; banks of open drains need protection against erosion
- poorly drained : drainage is a problem in bottomland areas and growing cane on the ridge is advisable; salinity may develop in the Bluebank, Katarra and Avoca series in the Dry Lowveld System
- irrigation : generally not recommended, but where practised good irrigation scheduling is essential
- timing : the sandy clay loam soils compact easily when wet and cap when dry, so planting should take place in spring or early summer; this ensures that the soil is well protected by the cane canopy in the rainy season
- low nutrient status : inherently low in nitrogen, phosphorus and potassium and possibly zinc; split applications of nitrogen and potassium are advisable; high levels of nitrogen may be required to balance nitrogen losses due to denitrification and leaching, particularly in wet years; leaf sampling is strongly recommended
- low available water capacity : exceptionally good surface water management and irrigation scheduling required
- nematodes : may be a problem where A horizon is very sandy

SELECTED PROPERTIES OF FERNWOOD FORM SOIL SERIES

Soil series	Physical					
	Clay % E horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Maputa	0 to 6 (fine sand)	Less than 80	Good	Excessive	Very high	cr, co, mw
Fernwood	0 to 6 (medium sand)	Less than 80	Good	Excessive	Very high	cr, co, mw
Langebaan	0 to 6 (medium sand)	Less than 80	Good	Excessive	Very high	cr, co, mw
Sandveld	0 to 6 (coarse sand)	Less than 80	Good	Excessive	Very high	mw
Warrington	0 to 6 (medium mottled sand)	80 to 100	Good	Moderate to poor	Very high	mw
Trafalgar	0 to 6 (coarse mottled sand)	80 to 100	Good	Moderate to poor	Very high	mw

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Nematode hazard
Maputa	5,0 to 6,5	Low to very low	Low to moderate	Low	Very low	Low	Low	Low	Severe
Fernwood	5,0 to 6,5	Low to very low	Low to moderate	Low	Very low	Low	Low	Low	Severe
Langebaan	7,0 to 8,5	Low to very low	Absent	Low	Very low	Low	Low	Low	Severe
Sandveld	5,0 to 6,5	Low to very low	Low	Low	Very low	Low	Low	Low	Severe
Warrington	5,0 to 6,0	Low	Low	Low	Very low	Low	Low	Low	Moderate to severe
Trafalgar	5,0 to 6,0	Low	Low	Low	Very low	Low	Low	Low	Moderate to severe

Correlation FAO

Dystric and Eutric Rhegosols

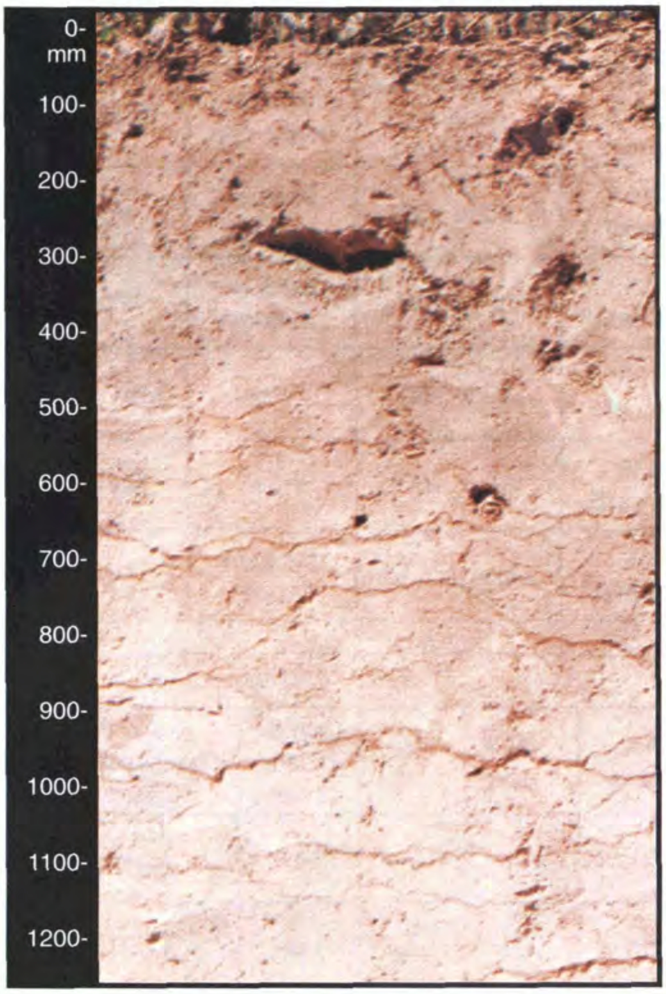
Correlation USDA

Entisols

Fernwood Form - Fw

Orthic A

E horizon



Grey to dark grey sand

Deep light grey to white loose sand sometimes with clay lamellae. In bottomland areas the subsoil shows mottling and yellow staining

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems (mainly Coastal Sands)	Grey Recend Sands Recent alluvium	Maputa	Fine sand	More than 1 200
		Fernwood	Medium sand	
		Langebaan (calcareous)	Medium sand	
		Sandveld	Coarse sand	
		Warrington (bottomland soil)	Medium sand	800 to 1 200
		Trafalgar (bottomland soil)	Coarse sand	

FEATURES TO NOTE

- field layout : soils are highly erodible and good conservation layouts are important; other measures include strip cropping and a trash blanket
- narrow row spacing : because cane growth is slow weeds are a problem and close row spacing will help rapid formation of the leaf canopy
- minimum tillage : is essential and will also combat wind erosion
- nematodes : are a serious problem and without a nematicide good yields will not generally be obtained
- low nutrient status : thorough soil sampling is required, as agricultural lime and zinc may be needed, in addition to high levels of nitrogen, potassium and possibly phosphorus
- iron chlorosis : a problem on fields that have been over-limed through excessive filtercake usage

SELECTED PROPERTIES OF LONGLANDS FORM SOIL SERIES

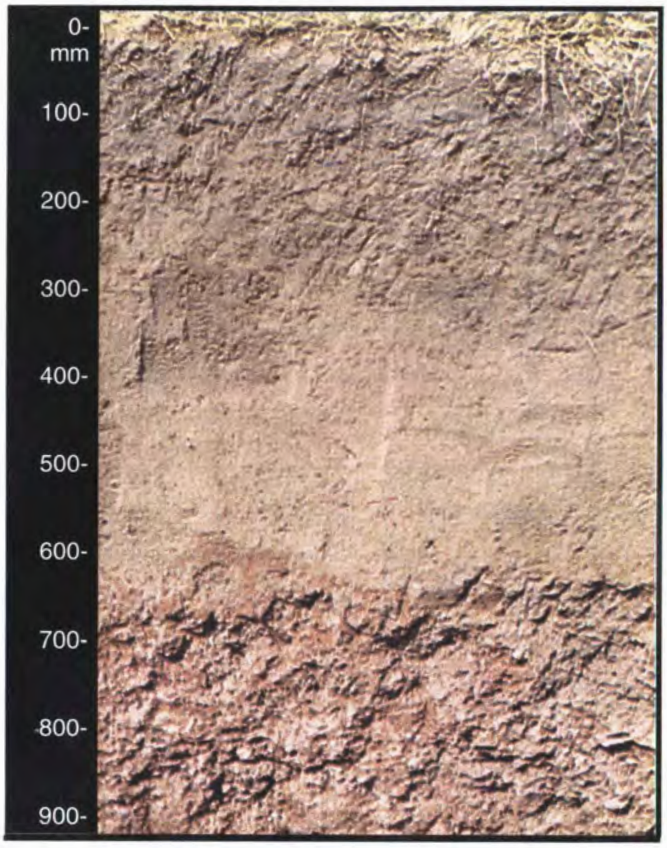
Soil series	Physical					
	Clay % E horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Waaisand	6 to 15 (fine sand)	80 to 100	Medium to poor	Poor	Very high	cr, co, sh
Longlands	6 to 15 (medium sand)	80 to 100	Medium to poor	Poor	Very high	cr, co, sh
Waldene	15 to 35 (fine sand)	80 to 100	Poor	Very poor	Very high	cl, cr, co, sh
Albany	15 to 35 (medium sand)	80 to 100	Poor	Very poor	High	cl, cr, co, sh
Vaalsand	6 to 15 (coarse sand)	Less than 80	Medium to poor	Poor	High	cr, co, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Waaisand	5,0 to 6,0	Very low	Low	Low	Low	Low	Low	Low	Low to moderate
Longlands	5,0 to 6,0	Low	Low	Low	Low	Low	Low	Low	Low to moderate
Waldene	5,0 to 7,0	Low to moderate	Absent	Low	Low	Low	Low	Moderate	Moderate
Albany	6,0 to 7,0	Low to moderate	Absent	Low	Low	Low	Low	Moderate	Moderate
Vaalsand	6,0 to 8,0	Moderate	Absent	Low	Low	Low	Low	Low	Moderate

FEATURES TO NOTE

- high erodibility : use minimum tillage; protect with a trash blanket or leave burnt tops scattered; do not cultivate
- poorly drained : drainage is poor in the bottomland areas and unless rectified, salinity problems may develop in the Albany and Vaalsand series
- irrigation : generally not recommended but, where practised, good irrigation scheduling is essential
- low available water capacity : exceptionally good surface water management and irrigation scheduling are required
- planting : cane should be planted on the ridge if a water table is present; however, if the soil is dry with no signs of a water table, then planting cane in a vertically mulched slot containing filtercake has given good results
- timing : the sandy clay loam soils compact easily when wet and cap when dry, so planting should take place in spring or early summer; this ensures that the soil is well protected by the cane canopy in the rainy season; harvesting should be planned for the dry winter months
- low nutrient status : inherently low in nitrogen, phosphorus and potassium and possibly zinc; split application of nitrogen and potassium are advisable; high levels of nitrogen may be required to balance nitrogen losses due to denitrification and leaching, particularly in wet years; leaf sampling is strongly recommended
- nematodes : nematicides may be effective in the sandy Waaisand series only

Longlands Form - Lo



Orthic A	Grey sandy loam to clay loam
E horizon	Bleached grey
Soft plinthic B	Mottled and gleyed with iron concretions

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Waaisand	Fine sandy loam	More than 1 000
Coastal Lowlands	Vryheid sediments Natal Group Sandstone Alluvium	Longlands	Medium sandy loam	500 to 800
	Vryheid sediments	Waldene	Fine sandy clay loam	400 to 800
	Dwyka tillite			
Dry Lowveld Humid Lowveld	Alluvium	Albany	Medium sandy clay loam	800 to 1 200
	Granite	Vaalsand	Coarse sandy loam	400 to 800

Correlation FAO

Plinthic Gleysols (with albic horizon)

Correlation USDA

Inceptisols
Alfisols

SELECTED PROPERTIES OF WASBANK FORM SOIL SERIES (NF)

Soil series	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Rondevlei	0 to 6	Less than 80	Very high	Poor	Very high	mw, sh
Kromvlei	6 to 15	80 to 100	High	Poor	High	cr, co, mw, sh
Wasbank	6 to 15	80 to 100	High	Poor	High	cr, co, mw, sh
Burford	15 to 35	100 to 140	Medium	Poor	Moderate	cl, cr, co, sh
Warrick	15 to 35	100 to 140	Medium	Poor	Moderate	cl, cr, co, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Rondevlei	5,0 to, 6,5	Low to moderate	Low	Low	Low	Low	Low	Low	Low to moderate
Kromvlei	5,0 to 6,5	Low to moderate	Low	Low	Low	Low	Low	Low	Low to moderate
Wasbank	6,0 to 7,5	Low to moderate	Absent	Low	Low	Low	Low	Low	Moderate
Burford	6,0 to 7,5	Low to moderate	Absent	Low	Low	Low	Low	Low	Moderate
Warrick	6,0 to 8,5	Moderate	Absent	Low	Low	Low	Low	Low	Moderate to high

NF - new form in this bulletin

Correlation FAO

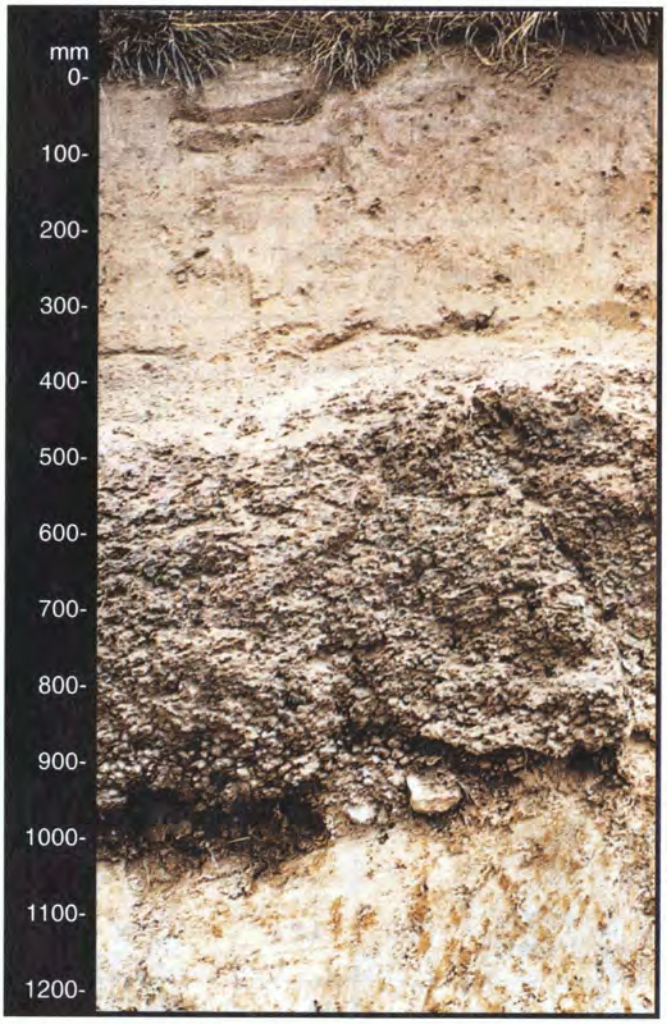
Plinthic Gleysols (with albic horizon)

Correlation USDA

Entisols

Wasbank Form - Wa

Orthic A	Grey sand to sandy loam
E horizon	Bleached grey
Hard plinthic B	Impermeable hard plinthic layer



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems except Coastal Sands and Mistbelt	Natal Group Sandstone	Rondevlei	Medium sand	300 to 500
	Dwyka tillite	Kromvlei	Medium loamy sand	
	Natal Group Sandstone Vryheid sediments	Wasbank	Medium loamy sand	
	Dwyka tillite	Burford	Sandy loam to sandy clay loam	
	Granite	Warrick	Sandy loam to sandy clay loam	

FEATURES TO NOTE

- non-arable : when effective rooting depth is less than 400 mm
- shallow profile : soil moisture retention is limited
- high erodibility : protect soils with a trash blanket or scattered tops; minimum tillage is essential
- planting : use minimum tillage and planting in the interrow, preferably with filtercake in a vertically mulched slot
- low nutrient status : high fertiliser rates would not generally be warranted because of the overriding limitations of soil depth and available moisture

SELECTED PROPERTIES OF CARTREF FORM SOIL SERIES

Soil series	Physical					
	Clay % E horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Cartref	6 to 15 (medium sand)	80 to 100	Medium to good	Moderate	High	cr, co, mw, sh
Arrochar	15 to 35 (fine sand)	100 to 140	Medium	Moderate to poor	High	cl, cr, co, mw, sh
Grovedale	0 to 6 (coarse sand)	Less than 80	Good	Moderate	High	cr, co, mw, sh
Kusasa	6 to 15 (coarse sand)	Less than 80	Medium to good	Moderate	High	cl, cr, co, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Cartref	5,0 to 7,0	Low	Low to moderate	Low	Low	Low	Low	Low to moderate	Low
Arrochar	6,0 to 7,0	Moderate	Absent	Low	Low	Low	Low	Moderate	Low
Grovedale	6,0 to 8,0	Low	Absent	Low	Low	Low	Low	Low to moderate	Low to moderate
Kusasa	6,0 to 8,0	Moderate	Absent	Low	Low	Low	Low	Low	Low to moderate

Correlation FAO

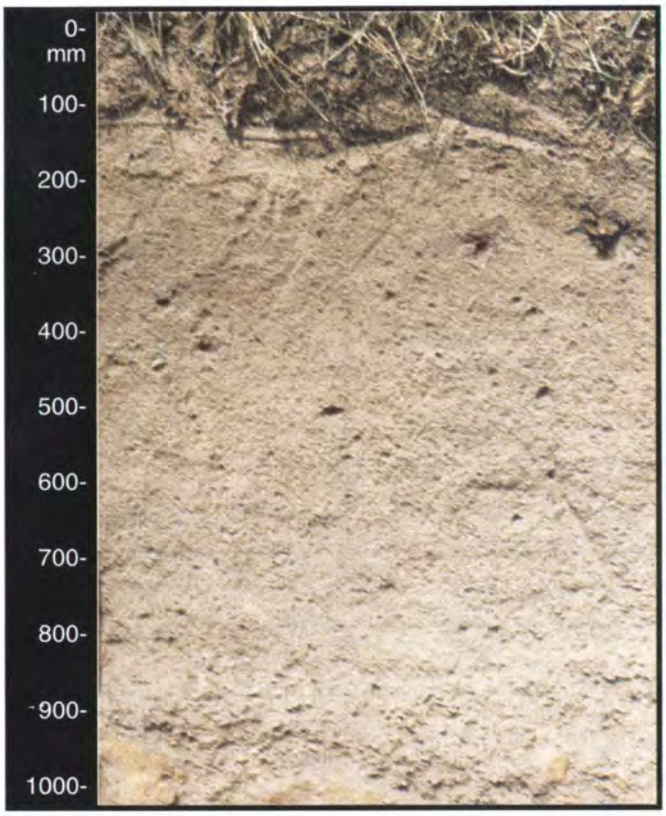
Gleyic Luvisols

Correlation USDA

Inceptisols

Cartref Form - Cf

Orthic A	Grey sand to sandy loam
E horizon	Bleached grey
Lithocutanic B	Soil tongues into weathering rock



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Coastal Lowlands	Natal Group Sandstone	Cartref	Medium loamy sand	500 to 1 200
	Dwyka tillite	Arrochar	Fine sandy loam	
Dry Lowveld Humid Lowveld	Granite	Grovedale	Coarse sand	400 to 1 000
	Granite	Kusasa	Coarse sandy loam	

FEATURES TO NOTE

- field layout : good conservation layout based on strip cropping is recommended
- planting : use minimum tillage, with planting in the interrow, preferably with filtercake in a vertically mulched slot
- high erodibility : protect with a trash blanket or burnt tops; do not cultivate; take care to stabilise waterways
- low nutrient status : commonly deficient in calcium and magnesium; potassium is always low, nitrogen requirements are higher than average and zinc may be deficient; split applications of fertiliser are recommended for all series except Arrochar
- nematodes : a response to nematicide may occur in sandy soils
- low available water capacity : exceptionally good surface water management is necessary
- irrigation : good irrigation control and short cycles are essential for the Grovedale and Kusasa series soils

SELECTED PROPERTIES OF VILAFONTES FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Alexandria	Less than 15	Less than 80	Good	Good	Very high	co, mw
Woburn	Less than 15	Less than 80	Good	Good	Very high	co, mw
Renishaw	More than 15	80 to 100	Good	Good	High	co, mw
Freeland	More than 15	80 to 100	Good	Good	High	co, mw

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Alexandria	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Woburn	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Renishaw	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Freeland	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low

NF - new form in this bulletin

Correlation FAO

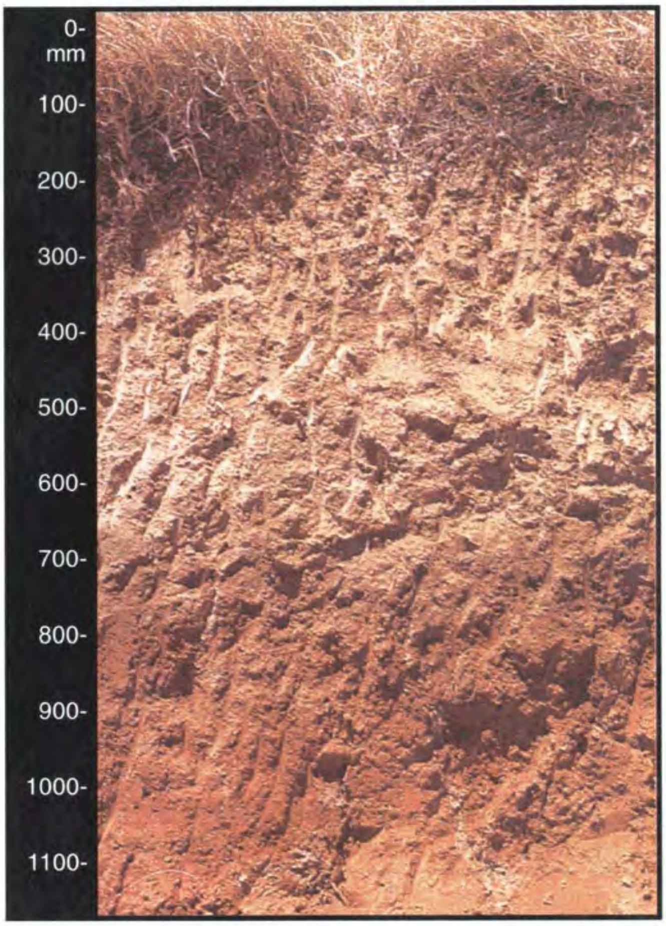
Albic and Glossic Luvisols

Correlation USDA

Alfisols

Vilafontes Form - Vf

Orthic A	Brown loamy sand
E horizon	Bleached grey or yellow
Neocutanic B	Red to non-red structureless sandy loam to sandy clay loam with variegated colours



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Colour of B horizon	Soil texture	Effective rooting depth (mm)
Coastal Sands Coastal Lowlands Hinterland	Recent Sands Alluvium Natal Group Sandstone	Alexandria	Non-red	Non-luvic B1 horizon	400 to 800
		Woburn		Luvic B1 horizon	
		Renishaw	Red	Non-luvic B1 horizon	
		Freeland		Luvic B1 horizon	

FEATURES TO NOTE

- minimum tillage : is essential in highly erodible sandy soils
- nematodes : will be a problem where the clay content is below 10%
- low nutrient status : higher than average amounts of fertiliser are needed as the nutrient status is inherently low

SELECTED PROPERTIES OF KLAPMUTS FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Napier	35 to 55	100 to 140	Medium to poor	Moderate to poor	High	cl, cr, co, sh
Mangeti	35 to 55	100 to 140	Medium to poor	Moderate to poor	High	cl, cr, co, sh
Bossieveld	35 to 55	100 to 140	Medium to poor	Moderate to poor	High	cl, cr, co, sh
Humansdorp	35 to 55	100 to 140	Medium to poor	Moderate to poor	High	cl, cr, co, sh

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Napier	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low in topsoil to moderate in subsoil	Low	Low to moderate in Dry Lowveld
Mangeti	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low in topsoil to moderate in subsoil	Low	Low to moderate in Dry Lowveld
Bossieveld	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low in topsoil to moderate in subsoil	Low	Low to moderate in Dry Lowveld
Humansdorp	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low in topsoil to moderate in subsoil	Low	Low to moderate in Dry Lowveld

NF - new form in this bulletin

Correlation FAO

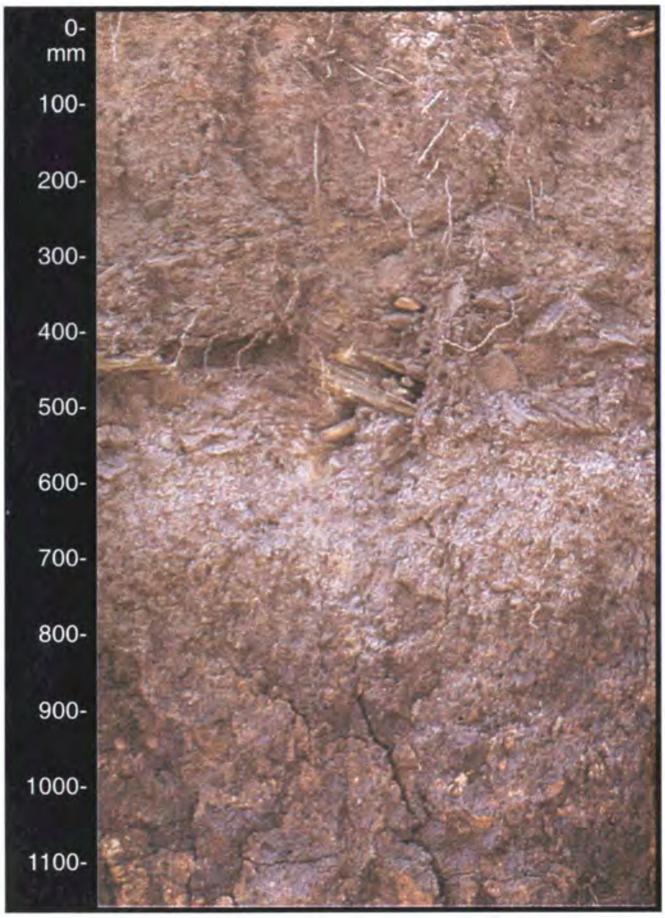
Chromic Luvisols (with albic horizon)

Correlation USDA

Aridisols

Klapmuts Form - Km

Orthic A		Grey sandy loam to sandy clay loam
E horizon		Bleached grey or yellow
Pedocutanic B		Blocky yellow-brown or red clay with variegated colours



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features		Effective rooting depth (mm)
			E horizon	B horizon	
Coastal Lowlands Hinterland Dry Lowveld	Dwyka tillite Vryheid sediments Tarkastad sediments	Napier	Grey	Non-red	400 to 600
		Mangeti	Grey	Red	
		Bossieveld	Yellow	Non-red	
		Humansdorp	Yellow	Red	

FEATURES TO NOTE

- conservation : highly erodible; use minimum tillage; protect with a trash blanket or leave burnt tops scattered
- subsoils : often highly erodible with dispersive clays
- planting : ridge planting is recommended in low lying areas
- timing : the sandy topsoils compact easily when wet so best to harvest in dry season
- nematodes : may be a problem where topsoil is very sandy
- nutrition : inherently low in nitrogen, phosphorus and potassium; high levels of N may be required as a split application

SELECTED PROPERTIES OF ESTCOURT FORM SOIL SERIES

Soil series	Physical					
	Clay % E horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Elim	0 to 6 (medium sand)	Less than 80	Medium to poor	Poor	Very high	cr, co, mw, sh
Uitvlugt	6 to 15 (medium sand)	80 to 100	Medium to poor	Poor	Very high	cr, co, mw, sh
Estcourt	15 to 35 (undifferentiated)	80 to 100	Poor	Very poor	Very high	cr, co, mw, sh
Rosemead	15 to 35 (undifferentiated)	80 to 100	Medium to poor	Poor	High	cr, co, mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Elim	6,0 to 9,0	Low to moderate	Absent	Low	Low	Low	Low	Low	High
Uitvlugt	6,0 to 9,0	Moderate	Absent	Low	Low	Low	Low	Low	High
Estcourt	6,0 to 9,0	Moderate to high	Absent	Low	Low	Low	Low	Low	High
Rosemead	5,0 to 7,0	Moderate to high	Absent	Low	Low	Low	Low	Moderate	Moderate to low

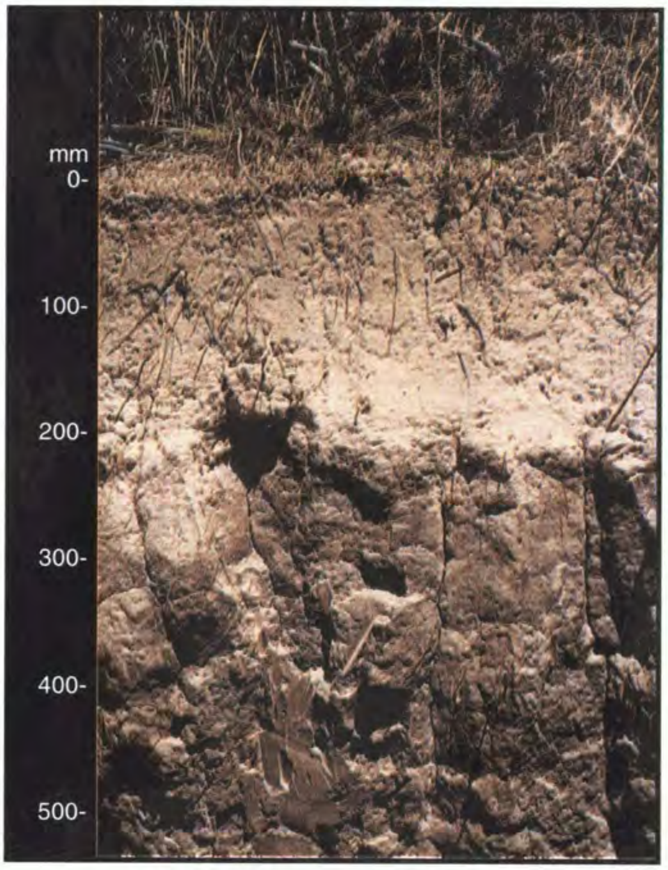
Correlation FAO

Ochric Solonetz (with albic horizon)

Correlation USDA

Alfisols

Estcourt Form - Es



Orthic A	Shallow grey to brown sand to sandy clay loam
E horizon	Bleached grey porous
Prismacutanic B	Slowly permeable olive-brown prismatic clay often with lime concretions

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
Dry Lowveld	Granite	Elim	Sand	300 to 600
	Vryheid sediments Dwyka tillite Tarkastad sediments	Uitvlugt	Loamy sand	
		Estcourt	Sandy loam	
Coastal Lowlands	Dwyka tillite	Rosemead	Fine sandy clay loam	

FEATURES TO NOTE

- non-arable : when effective rooting depth less than 400 mm
- irrigation problems : a low available water capacity, shallow depth, low intake rate and poor drainage make good irrigation scheduling essential
- poorly drained : installation of drains is essential to avoid a salinity hazard
- land smoothing : surface water management is very important
- high erodibility : the easily dispersed topsoil is highly erodible so land must be well protected and minimum tillage is recommended once fields have been levelled and smoothed
- planting : planting on the ridge is recommended
- timing : these soils compact easily when wet and cap when dry, so planting should take place in spring or early summer; this ensures that the soil is well protected by the cane canopy in the wet season; harvesting should be planned for the dry winter months
- low nutrient status : inherently low in phosphorus and potassium, so soil and leaf sampling are particularly important; higher than average levels of nitrogen are generally required, and splitting of N and K fertiliser is recommended
- nematodes : nematicides may be effective in the Elim series only

SELECTED PROPERTIES OF SHEPSTONE FORM SOIL SERIES

Soil series	Physical						
	Clay %		Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
	E* horizon	B horizon					
Bitou	0 to 6	Less than 15	Less than 80	Good	Good	Very high	cr, co
Shepstone	0 to 6	More than 15	100 to 140	Good	Good to moderate	Very high	cr, co, mw
Robberg	6 to 15	Less than 15	Less than 80	Good	Good	High	mw
Portobello	6 to 15	More than 15	100 to 140	Good	Good to moderate	High	mw

*Medium sand predominant in all four soil series

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Nematode hazard
Bitou	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Moderate to severe
Shepstone	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low	Low	Moderate to severe
Robberg	5,0 to 7,0	Low to moderate	Low	Low	Low	Low	Low	Low	Moderate
Portobello	5,0 to 7,0	Moderate to low	Low	Low	Low	Low to moderate	Low	Low	Moderate

Correlation FAO

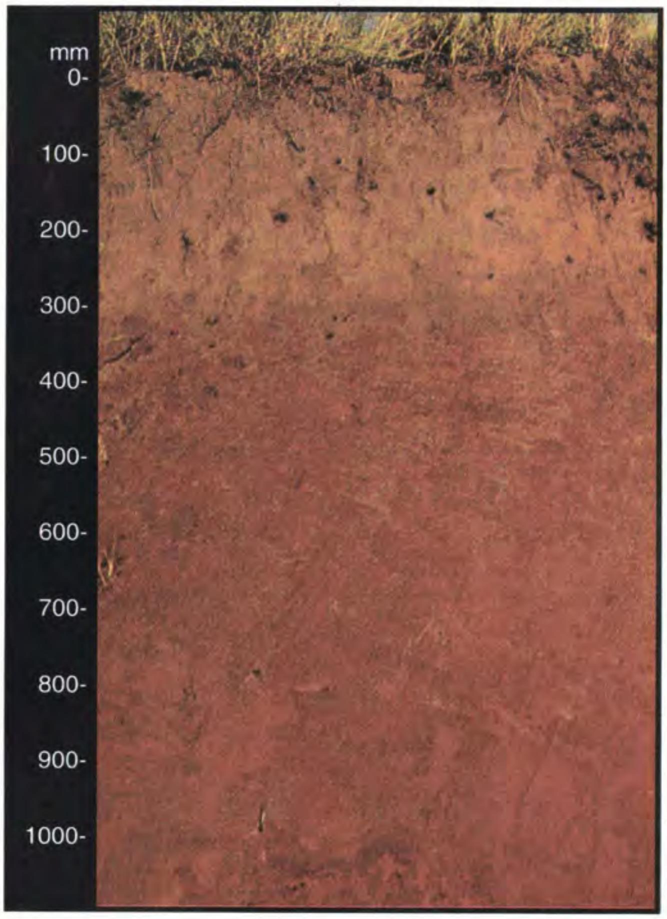
Albisols
Albic Luvisols

Correlation USDA

Spodosols
Alfisols

Shepstone Form - Sp

Orthic A	Grey sand to loamy sand
E horizon	Bleached grey or white
Red apedal B	Red loamy sand to sandy clay loam



MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Subsoil (red)	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Bitou	Medium sand	Loamy sand	More than 800
		Shepstone		Sandy clay loam	
		Robberg	Medium loamy sand	Loamy sand	
		Portobello		Sandy clay loam	

FEATURES TO NOTE

- conservation : as the soils are highly erodible, good conservation layouts are important, as well as practices such as strip cropping and a trash blanket
- minimum tillage : is essential and will also combat wind erosion
- nematodes : in the very sandy topsoils nematicides should be used
- low nutrient status : higher than average amounts of fertiliser are needed as the soil nutrient status is inherently low; splitting of N and K fertiliser is recommended
- variety : where topsoils are very sandy select varieties best suited to sandy soils, but where clay in topsoil is greater than 8% select high yielding varieties

SELECTED PROPERTIES OF CONSTANTIA FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % B2 horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Potberg	Less than 15	Less than 80	Good	Good	Very high	co, mw
Philippi	Less than 15	Less than 80	Good	Good	Very high	co, mw
Papegaaikop	More than 15	80 to 100	Good	Good	High	co, mw
Thesen	More than 15	80 to 100	Good	Good	High	co, mw

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Potberg	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Philippi	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Papegaaikop	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low
Thesen	5,0 to 7,0	Low	Low	Low	Low	Low	Low	Low	Low

NF - new form in this bulletin

Correlation FAO

Albisols
Ferric Podzols

Correlation USDA

Spodosols
Alfisols

Constantia Form - Ct

Orthic A	Grey sand
E horizon	Bleached grey
Yellow-brown apedal B	Yellow-brown structureless loamy sand to sandy clay loam

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features		Effective rooting depth (mm)
			B horizon	Signs of organic matter and soft plinthite below B horizon	
Coastal Sands	Recent Sands	Potberg	Non-luvic	Absent	600 to 1 200
		Philippi	Non-luvic	Present	
Coastal Lowlands	Natal Group Sandstone Vryheid sediments	Papegaaikop	Luvic	Absent	
		Thesen	Luvic	Present	

FEATURES TO NOTE

- nematodes : are a serious problem and without nematicide good yields will not be obtained
- minimum tillage : is essential in these highly erodible soils and will also combat wind erosion
- narrow row spacing : because weeds are a problem, close row spacing will help
- trashing : protect with a trash blanket or leave burnt tops scattered
- low nutrient status : higher than average amounts of fertiliser are needed as the nutrient status is inherently low; splitting of N and K fertiliser is recommended

SELECTED PROPERTIES OF DUNDEE FORM SOIL SERIES

Soil series	Physical					
	Clay %	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Dundee	Variable	100 to 140	Good	Moderate	Moderate	mw, sh

Soil series	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Dundee	5,0 to 7,0	High to very high	Absent	Low	Low	Moderate	Moderate to high	High	Low

Correlation FAO

Eutric and Carbonatic Fluvisols
Dystric and Gleyic Fluvisols (possibly)

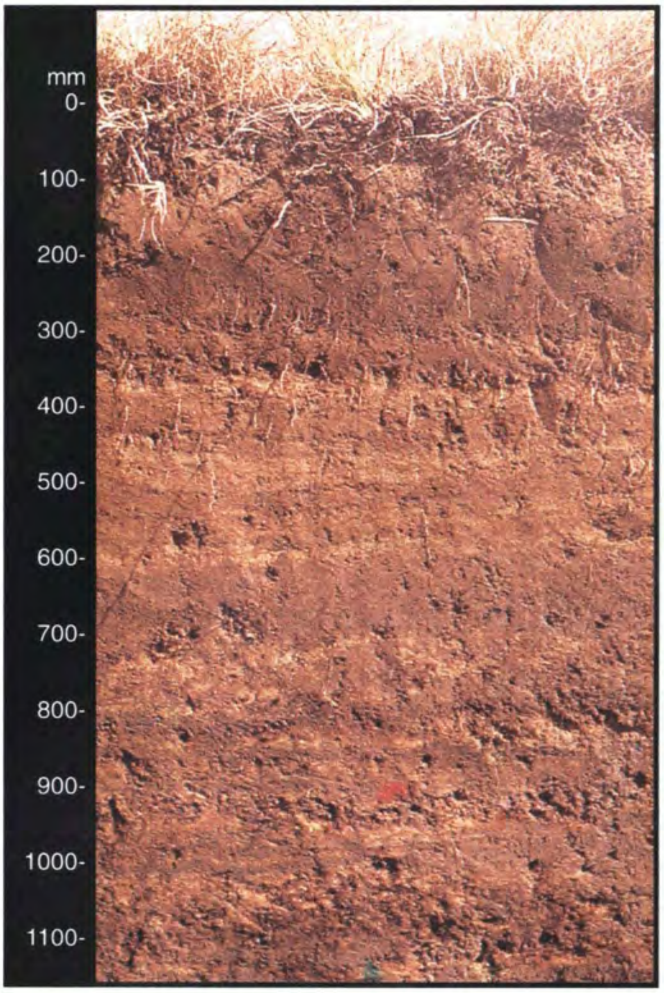
Correlation USDA

Entisols
Aridisols

Dundee Form - Du

Orthic
A

Stratified
alluvium



Dark
grey-brown
loamy sand
to sandy
clay loam

Alternating
layers of sand
and clay
sometimes
merging into
heavy gley

MAIN SOIL SERIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil series	Topsoil texture	Effective rooting depth (mm)
All systems	Alluvium (recent)	Dundee	Variable	More than 1 000

FEATURES TO NOTE

- properties : physical and chemical properties are good
- tillage : cultivation of stratified topsoil desirable for uniform rooting
- varieties : these soils are well suited to high potential varieties
- nutrient status : generally high, so fertiliser requirements usually low; soil sampling important
- nematodes : some sandy alluvial soils benefit from the use of a nematicide
- flooding : a likely hazard in summer, so plan field operations for winter and spring
- irrigation : subsurface water tables may be present and will need to be considered when scheduling irrigation

SELECTED PROPERTIES OF NAMIB FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Nortier	5 to 10	80 to 100	High	High	High	mw
Beachwood	5 to 10	80 to 100	High	High	High	mw
Kalahari	5 to 10	80 to 100	High	High	High	mw
Henkries	5 to 10	80 to 100	High	High	High	mw

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Nematode hazard
Nortier	5,0 to 6,5	Low to very low	Low	Low	Very low	Low	Low	Low	Severe
Beachwood	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Very low	Low	Low	Low	Severe
Kalahari	5,0 to 6,5	Low to very low	Low	Low	Very low	Low	Low	Low	Severe
Henkries	7,0 to 8,5	Low to moderate	Absent	Low to moderate	Very low	Low	Low	Low	Severe

NF - new form in this bulletin

Correlation FAO

Dystric Rhegosols

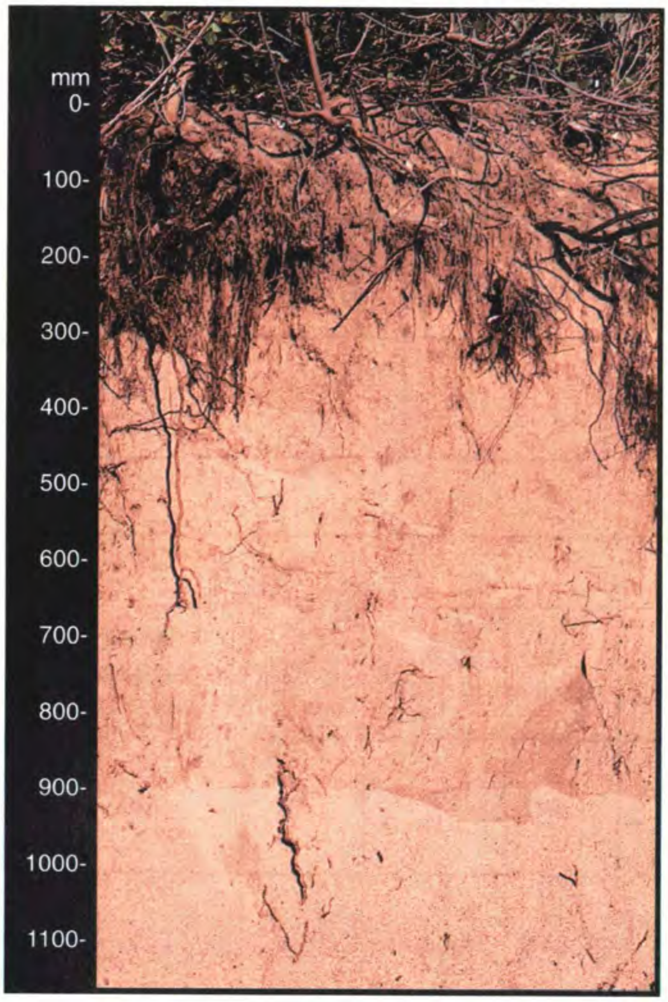
Correlation USDA

Entisols

FEATURES TO NOTE

- field layout : soils are highly erodible and good conservation layouts are important; other measures include strip cropping and a trash blanket
- minimum tillage : is essential in these sandy soils and will also combat wind erosion
- nematodes : are a serious problem; without a nematicide good yields will not generally be obtained
- low nutrient status : thorough soil sampling is required as agricultural lime and zinc may be needed in addition to high levels of nitrogen, potassium and possibly phosphorus
- iron chlorosis : a problem on fields that have been over-limed through excessive filtercake usage
- narrow row spacing : because cane growth is slow weeds are a problem and close row spacing will help rapid formation of the leaf canopy
- variety : choose those best suited to sandy soils

Namib Form - Nb



Orthic A	Grey to dark grey sand
Regic sand	Deep light grey to white loose sand sometimes with clay lamellae; in bottomland areas the subsoil shows mottling and yellow staining

MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features	Effective rooting depth (mm)
Coastal Sands	Recent Sands	Nortier	Non-red regic sand and non-calcareous within 1 500 mm of the soil surface	More than 1 000
		Beachwood	Non-red regic sand and calcareous within 1 500 mm of the soil surface	
		Kalahari	Red regic sand and non-calcareous within 1 500 mm of the soil surface	
		Henkries	Red regic sand and calcareous within 1 500 mm of the soil surface	

SELECTED PROPERTIES OF WITBANK FORM SOIL FAMILIES (NF)

Soil families	Physical					
	Clay % A horizon	Available water capacity (mm/m)	Steady intake rate	Drainage	Erosion hazard	Tillage constraints
Thornlea	5 to 50	80 to 140	Moderate to poor	Moderate to poor	Low to high	cl, cr, co, mw, sh
Nuwewerf	5 to 50	80 to 140	Moderate to poor	Moderate to poor	Low to high	cl, cr, do, mw, sh

Soil families	Chemical								
	Soil pH	Base status	Al toxicity	P fixation	Organic matter content	N and S mineralisation capacity	K reserves	Zn reserves	Salinity/ sodicity hazard
Thornlea	5,0 to 7,0	Low to moderate	Low	Low to moderate	Low	Low	Low	Low	Low
Nuwewerf	6,0 to 8,5	Moderate to high	Absent	Moderate	Low	Low	Low	Low	Low to moderate

NF - new form in this bulletin

Correlation FAO

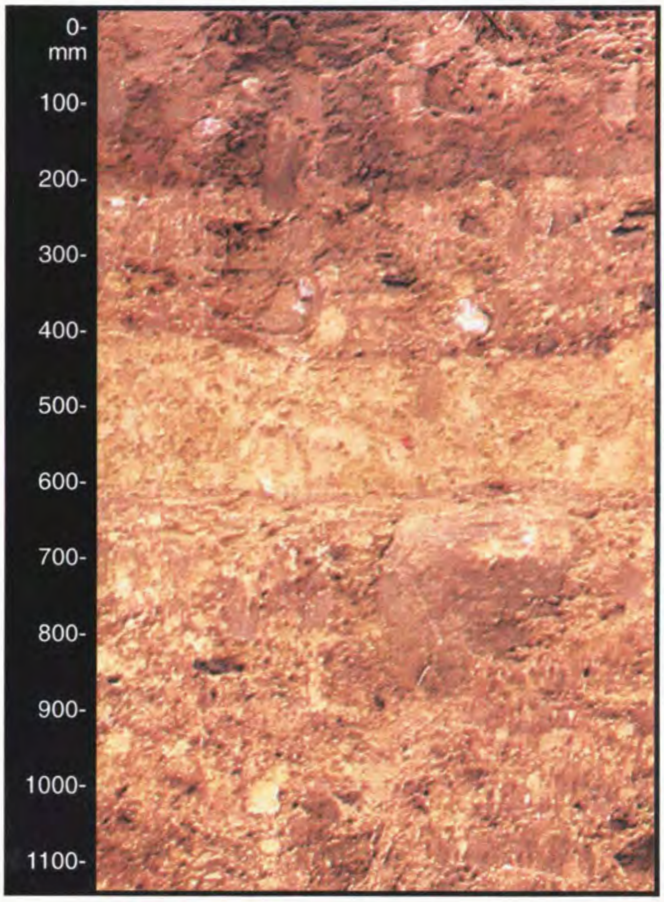
Anthrosols

Correlation USDA

Not specifically catered for

Witbank Form - Wb

Orthic A	Topsoil
Man-made soil deposit	All landfills, mine dumps, road embankments, builders' rubble, levelled sports fields, etc.



MAIN SOIL FAMILIES, TEXTURE AND DEPTH

Soil system	Parent material	Soil families	Main features	Effective rooting depth (mm)
All systems	All parent materials	Thornlea	Non-calcareous within 1 500 mm of the soil surface	150 to 1 500
		Nuwewerf	Calcareous within 1 500 mm of the soil surface	

FEATURES TO NOTE

- land smoothing : surface water management must be good, as intake rate and drainage are variable
- variable nutrient status : these soils should be thoroughly sampled to establish the nutrient status; excessive subsoil fill will require an above average P requirement
- irrigation : poor intake rate and drainage coupled with a possible salinity hazard in the Nuwewerf family makes good irrigation scheduling essential

GUIDE TO THE MANAGEMENT OF SOILS

INTRODUCTION TO THE MAIN SOIL GROUPS

- Many of the decisions a grower must take on his farm are affected by soil types. These decisions include systems of land preparation for re-establishing cane, the optimum time to harvest, trash management, nutrition, weed control, variety selection, the use of agricultural chemicals, irrigation systems and methods of controlling erosion.

- Only brief reference has been made to some of these management practices for each of the soil forms in the Soils Bulletin under 'Features to note' below the colour plates.

- To facilitate a more complete consideration of these management practices, the 49 soil forms described in the Bulletin have been divided into five main groups according to colour and texture, being further divided into sub-groups based on position in the landscape as shown in Table 1 (page 139).

- **Soil phases** have considerable relevance when considering soil management. A **soil phase** is a sub-division below the soil series and the soil family, e.g. a Shortlands form soil may have stony/rocky, steep or shallow phases which could have major economic consequences for the farmer.

SOIL GROUPS AND PROPERTIES

Dark brown humic soils (8% of the industry)

This soil group is confined to old land surfaces in the KwaZulu-Natal Midlands (310 to 1 200 m) and coincides roughly with the so-called Mistbelt area. Topsoils are deep dark brown porous sandy loams and clay loams rich in organic matter, overlying well weathered red and yellow acid clay loam subsoils.

Physical

- Porous, well drained with high available water capacity (140 to 180 mm/m) and deep effective rooting depth.
- Fluffy consistency due to high organic matter content, but can pulverise if overworked and become dusty.
- Relatively resistant to erosion and easy to work.

Chemical

- Moderately to strongly acid – average topsoil pH 5,4 and subsoil pH 4,5.
- Gives rise to moderate to high aluminium toxicity and marked phosphorus fixation.
- Soils mineralise considerable amounts of nitrogen.
- Low reserves of phosphorus, potassium, calcium, magnesium and zinc.

Black soils (13% of the industry)

In this group soils are mainly derived from Swaziland basic rocks, dolerite, basalt, Pietermaritzburg shales and alluvium. They are found throughout the South African sugar industry, from the Mpumalanga lowveld in the north to the south coast of KwaZulu-Natal, including inland areas up to 700 m altitude, particularly in river valleys and rain shadow areas.

The soils range from moderately shallow black swelling clay (Arcadia form) to black blocky clay overlying shale (Milkwood form) and black swelling clay overlying heavy mottled gley (Rensburg form). The main characteristics of black soils are:

Physical

- Moderate water holding capacity (130 to 170 mm/m) and limited effective rooting depth.
- Low capillary conductivity and marked moisture retention.
- High shrink/swell potential.
- Sticky when wet, cloddy when dry, so difficult to work.
- Low intake rate when wet and slow internal drainage.

Chemical

- Can mineralise moderate amounts of nitrogen.
- Well supplied with calcium and magnesium.
- Moderate reserves of phosphorus and potassium.
- Sensitive to sodium.
- Moderate to high salinity hazard where drainage is poor.

Red and yellow-brown soils (19% of the industry)

These two groups are very dominant in the northern irrigated areas (57%) and the midlands (34%), but less extensive in the coastal lowlands (15%). Additional descriptions and locations of the two groups include:

- Deep red windblown loamy sands to sandy loams along the coast.
- Deep dark reddish-brown blocky clays derived from dolerite along the north and south coasts, from basalt and schist in Zululand and alluvium in Pongola.
- Dark reddish clays with stone inclusions occur in Mpumalanga and are derived from Swaziland basic rocks.
- Moderately deep red gritty sandy loams derived from basement granite occur in the drier inland valleys of the Hinterland as well as in Mpumalanga.
- Both red and yellow-brown sandy loams to heavy clays are associated with a range of parent materials in the midlands, and with very variable base status.

Their main characteristics are as follows:

Physical

- Available water capacity variable but usually good (80 to 180 mm/m).
- Normally well drained and aerated, with good steady intake rate.
- Blocky structured red soils are resistant to erosion, but light textured red and yellow-brown soils are highly erodible.
- Blocky structured red soils are difficult to work when too wet or too dry.

Chemical

- Soil pH very variable (alkaline in the lowveld to strongly acid in the midlands).
- Have moderate levels of organic matter, so considerable potential to mineralise nitrogen.
- Inherently low in phosphorus and fix P in the midlands.
- Degree of leaching very important in this group.
- Lime often required in the midlands to overcome aluminium toxicity.
- Adequate reserves of calcium and magnesium in the coastal lowlands and lowveld.

Grey soils (60% of the industry)

On the north coast and Zululand, grey medium loamy sands of the Cartref form, derived from Natal Group Sandstone, comprise the most important soil group, followed by fine sandy clay loams of the Glenrosa form often associated with Dwyka tillite. Soils in this category (excluding the Fernwood form) are characterised by rather severe limitations, such as:

Physical

- Low available water capacity (60 to 80 mm/m).
- Prone to compaction when wet.
- Steady intake rate poor, especially in soils which crust.
- Restricted internal drainage.
- High erodibility hazard.
- Nematode hazard probable where clay is less than 8%.

Chemical

- Low organic matter content, thus a low potential to mineralise nitrogen.
- Low reserves of all major nutrients.
- High salinity/sodicity hazard in the lowveld.

Table 1. Description of the main soil groups

Soil group	Toposequence	*Soil management unit	Representative soil forms	Distribution
BROWN HUMIC SANDY LOAMS TO CLAY LOAMS AND ORGANICS	crest to midslope	BHcms	Nomanci, Inanda, Kranskop, Magwa, Lusiki	Found mainly in the Midlands mistbelt and associated with mainly Natal Group Sandstone, dolerite and Vryheid sediments
	footslope	BHfs	Sweetwater	
	valley	BHv	Champagne	
BLACK BLOCKY CLAYS	crest to midslope	Bcms	Arcadia, Mayo, Milkwood, Bonheim (red)	Found in all areas of the sugar industry except the Midlands mistbelt. Mainly derived from dolerite and Pietermaritzburg shales
	footslope to valley	Bfsv	Bonheim (non-red), Inhoek, Willowbrook, Rensburg	
RED LOAMY SANDS TO CLAYS	crest to midslope	Rcms	Hutton, Augrabies, Oakleaf (red), Bonheim (red), Swartland (red), Shortlands	Found in all areas of the industry on a wide range of parent materials
	footslope	Rfs	Bainsvlei, Bloemdal, Shepstone	
YELLOW-BROWN LOAMY SANDS TO CLAYS	crest to midslope	Ycms	Clovelly, Griffin	Commonly found in the Midlands area and associated with Natal Group Sandstone, Dwyka tillite and Vryheid sediments
	footslope	Yfs	Avalon, Glencoe, Constantia, Pinedene	
GREY SANDS TO SANDY CLAY LOAMS	crest	Gc	Mispah, Glenrosa	The most common soil group in the industry, derived mainly from Natal Group Sandstone and Granite parent material
	midslope	Gms	Cartref, Oakleaf, Dresden, Swartland	
	footslope	Gfs	Valsrivier, Klapmuts, Sepane, Longlands, Westleigh, Wasbank, Sterkspruit, Estcourt	
	valley bottom	Gv	Kroonstad, Katspruit	
	recent deposit (young soils)	Gr	Oakleaf, Vilafontes, Tukulu, Namib, Fernwood, Dundee, Witbank	

***Abbreviations used in the soil management units:**
BH = brown humic, B = black, R = red, Y = yellow, G = grey
c = crest, cms = crest to midslope, ms = midslope, fs = footslope,
fsv = footslope to valley bottom, v = valley bottom, r = recent deposit

SURFACE WATER MANAGEMENT AND FIELD LAYOUT

Cane fields are most vulnerable to soil erosion at the time of re-establishment. All cane lands need good surface water management to reduce runoff and soil loss. Much of the rainfall in South Africa is either of a high intensity or of long duration, resulting in high rates of surface runoff and soil loss. Erodible soils on steep slopes need the greatest degree of management, while resistant soils on gentle slopes need less. In general, the shallow soils of the grey group have the highest erodibility rating and surface runoff potential. Most land needs:

- Correctly spaced, large water carrying conservation terraces, of suitable shape, length and gradient.
- Relocation of poorly sited waterways, ensuring that they are prepared and shaped according to the recommended dimensions.
- Elimination of minor high spots and filling in local hollows or rills by careful land shaping and smoothing.
- Maintenance of an effective vegetative canopy or cover, including green manuring and green cane harvesting.
- Longer ratoon cycles – the less frequent the re-establishment the better.
- Contour row alignment and tillage, or better still 'master row' alignment and tillage, especially where ridge or furrow planting is practised.
- Strip eradication, planting and harvesting.
- Minimum tillage, including both chemical eradication of the old crop and hand chipping.
- Timing of all vulnerable operations to avoid the summer storms.

Water carrying conservation terraces

- Essential for all soils on steep as well as gentle slopes.
- Spacing of terraces is dependent on soil erodibility, land slope, rainfall erosivity and management practices. A terrace spacing nomograph has been developed at SASEX for maximum permissible spacing but should be modified based on experience and in order to facilitate an integrated farm plan.
- Terraces should have the flattest accelerating gradients possible, depending on soil, slope and topographic position. Acceptable gradients range from 0,1 to 1,0% (1:1 000 to 1:100).
- Parallel terraces on uniform slopes forfeit optimum channel gradient but improve mechanical and irrigation efficiency.
- Terraces should not exceed 500 m in length, although topography often dictates shorter terraces. They should discharge into stable grassed waterways or water courses. They need special protection at their discharge ends where they spill directly into deep water courses.
- Terrace capacity should be as large as possible to reduce maintenance and avoid overtopping even in high intensity storms.

Roads

- Sugarcane needs good crop extraction roads due to its bulky nature.
- Well cambered crest roads and conservation terraces are all that are needed for crop extraction on land slopes of less than 12%.
- On steeper land some diagonal roads with 10 to 12% gradients are necessary as crests are usually too steep.
- All diagonal roads need special drainage. Mitre drains at 10 to 15 m spacing are recommended on erodible soils.

Grassed waterways

- All waterways should be well grassed and properly designed for hydraulic stability.
- Stable grassed waterways accumulate sediment at the rate of 10 to 20 mm per annum, so they do have to be 0,4 to 0,5 m deep and reshaped every 15 to 20 years.

Row alignment

- All cane rows should be free draining over their entire length, especially where ridge planting is practised.
- All cane rows should bend uphill onto cambered crest or diagonal roads and they should bend down towards waterways and water courses.

FIELD DRAINAGE

Waterlogging can be caused by any one or a combination of the following:

- Heavy, low lying soils with slow internal drainage.
- Low lying lands with restricted runoff.
- Soils with impermeable or gleyed horizons.
- Sodic or dispersed soils.
- The application of too much water (a major factor in irrigated areas).

True wetland should not be drained, but rather left to perform its natural function of filtering and purifying flood waters and sustaining base flow. Where wet cane land needs drainage, professional help should be sought.

LAND PREPARATION AND RE-ESTABLISHING CANE

Soil type and slope should guide the grower in deciding on:

- Whether green manuring should be practised.
- Whether minimum tillage should be used instead of conventional tillage.
- The method of eradicating the old crop.
- Whether strip planting and harvesting should be practised.
- The method and timing of seedbed preparation.
- Optimum row spacing and alignment.

Green manuring and fallow management

- There is recent renewed interest in this practice as a means of improving soil physical and chemical conditions as well as decreasing the incidence of pests and diseases.
- Suitable crops for rejuvenating old cane land include velvet beans, sunnhemp, soyabeans, groundnuts, cowpeas, lupins, rape, buckwheat and mungbeans.
- In Swaziland, green manuring is used commercially on duplex soils with a history of cane yield decline. Yield improvements have been substantial.
- Yield increases were ascribed to more prolific rooting brought about by improved soil physical properties, particularly lower bulk density. Intake rate and resistance to penetration were also significantly improved as well as soil organic matter levels.
- Compared with a bare fallow, green manuring will have important conservation benefits, particularly on the erodible grey sandy soils.

Minimum tillage

- Cane fields are particularly vulnerable to erosion when they are ploughed and fallowed before replanting and before the plant crop has become established.
- All cane land above 20% land slope, should be re-established using the minimum tillage technique as a general norm. However, erodible sandy soils need minimum tillage above 10% slopes.
- The highly erodible grey group of soils derived from Dwyka tillite, Vryheid sediments, Granite and NGS are particularly vulnerable because soils tend to be shallow and poorly structured. They should be disturbed as little as possible during land preparation and protected as much as possible in subsequent operations.
- Experiments have shown that the minimum tillage system based on the use of chemicals is the most efficient conserver of soil and moisture. Compared with the conventional system of land preparation it has been shown to improve yields in a range of soils.
- Other measured benefits included increased soil organic matter content, and reduced soil bulk density and runoff. The recommended system of land preparation and other practices based on slope and the erodibility of soils is summarised in Table 2.

Strip farming

- A cane field should consist of not more than three adjacent contour panels.
- Preferably every third field down a slope should be harvested (i.e. cut one, skip two). This greatly facilitates controlled burning at harvest and provides protection from wild fires.

Table 2. Recommended system of land preparation according to soil group

Soil group	Soil management unit	Representative soil forms	Erosion hazard	Recommended land preparation system	Other beneficial practices
BROWN HUMIC LOAMS	BHcms	Nomanci, Inanda, Kranskop	Usually low except slopes >20%	Slopes >20% minimum tillage (MT) obligatory	Strip planting and vertical mulching with lime, filtercake or poultry manure
	BHfs	Sweetwater, Lusiki, Magwa	Low	Slopes <20% MT/combination tillage or conventional shallow mouldboard (100 mm) plough with depth wheel	
BLACK BLOCKY CLAYS	Bcms	Arcadia, Mayo, Milkwood, Bonheim	Usually low except slopes >20%	Slopes >20% MT and strip planting	Green manuring and trashing
	Bfs Bv	Bonheim, Inhoek, Willowbrook, Rensburg	Low	Slopes <20% MT/combination tillage or conventional shallow mouldboard (100 mm) plough with depth wheel	Mole drainage in wet areas; slotted drains; ridge planting
RED AND YELLOW SANDY LOAMS TO CLAYS	Rcms Yms	Hutton, Oakleaf (red), Shortlands, Clovelly, Griffin	Moderate, except on steep slopes and lighter soils	Slopes >15% and heavy soils, MT and strip planting	Green manuring and trashing
	Rfs Yfs	Bainsvlei, Bloemdal, Avalon, Pinedene		Slopes <15% and lighter soils, strip planting and MT or conventional shallow ploughing (100 mm)	Green manuring; mole drains where clay is >30% in subsoil; ridge planting
GREY, RED AND YELLOW SANDS TO SANDY LOAMS	Gcms Rcms Ycms	Glenrosa, Cartref, Oakleaf, Hutton, Shepstone	Severe to very severe	Slopes >10% MT and strip planting using close panel widths	Green manuring and trashing
	Gr Rr Yr	Valsrivier, Sepane, Dundee	Moderate to severe	Slopes <10% MT/combination tillage or rotary hoe	Green manuring
	Gfs Rfs Yfs	Oakleaf, Vilafontes, Tukulu, Namib, Fernwood	Severe	Slopes >10% strip planting, with MT or combination tillage	Green manuring
	Gv	Longlands, Westleigh, Kroonstad			Open drains; ridge planting

Stool eradication

- Preparing volunteer free fields is extremely important to prevent the spread of disease from volunteer plants to the clean, disease free seedcane. **Mechanical methods of stool eradication** are only effective during the dry winter months. Research by SASEX staff showed that a shallow mouldboard plough fitted with depth wheels to keep the operating depth at about 100 mm, followed by a discing or power harrowing was the most effective method of eradicating stools in clay loam to clay soils.
- Other alternatives are **sweeps or blade ploughs**, operating at the same depth. Blade type implements are not effective in sandy soils because they tend to bulldoze rather than shear the stools cleanly from their roots. Instead rotary hoe implements are recommended for sandy soils, but again only during dry periods.
- **Chemical eradication** of the old crop (minimum tillage) is only effective when the chemical is applied to actively growing cane. Spraying cane in the early growing season can lead to variable results and the risk of regrowth especially on heavier, more fertile soils. An acceptable procedure is to slash back any regrowth, to encourage tiller formation. The cane is then sprayed when it reaches knee height (500 mm).
- A more suitable method for eradicating the crop in spring is to use a **combination tillage technique**. The crop is sprayed with chemical, followed by mechanical shearing of the cane stools 100 mm below the ground surface 3-7 days after spraying. This practice severs the stool from the cane roots, leaving the stool in an upright position.
- **Hand chipping**, where the old stools are removed by modified hoes, can be a viable and cost effective alternative to both mechanical and chemical stool eradication, especially on lighter soils and on steep topography. The main advantage of chipping is that it can be done during dry winter periods, with follow-up roguings before the seedbed is prepared in spring.

The recommended methods of crop eradication for the different soil groups are summarised in Table 3.

Table 3. Stool eradication selection guide

Soil group	Soil management unit	Erosion hazard	Slope	Season	Method
BROWN HUMIC LOAMS TO CLAY LOAMS	BHcms BHfs	Low >20% clay	<20%	Winter	Shallow mouldboard plough (100 mm)
				Spring	Combination tillage with Fusilade
				Summer	Combination tillage with glyphosate or Touchdown
BLACK AND RED BLOCKY CLAYS	Bcms Rcms	Low >20% clay	>20%	Winter	Chipping
				Spring	Fusilade
				Summer	Glyphosate or Touchdown
RED, YELLOW AND GREY SANDY LOAMS TO SANDY CLAY LOAMS	Rcms Yms Gms Gfs	Moderate 15-35% clay	<15%	Winter	Shallow mouldboard plough or chipping
				Spring	Combination tillage with Fusilade
				Summer	Combination tillage with glyphosate or Touchdown
			>15%	Winter	Chipping
				Spring	Combination tillage with Fusilade
				Summer	Combination tillage with glyphosate or Touchdown
GREY SANDS TO LOAMY SANDS	Gc Gms Gr Gv	High <15% clay	<10%	Winter	Chipping or rotary hoe
				Spring	Chipping or combination tillage
				Summer	Chipping or glyphosate or Touchdown
			>10%	Winter	Chipping
				Spring	Chipping or combination tillage
				Summer	Chipping or glyphosate or Touchdown

TILTH AND TIMING OF SEEDBED PREPARATION

The fundamental reasons for ploughing and cultivating sugarcane soils are to destroy an old crop and to prepare a weed free seedbed before planting a new crop. It is still widely believed that deep tillage should form an integral part of seedbed preparation. Certain soil and climatic conditions or the deep placement of ameliorants may require deep tillage, but generally this expensive operation is not necessary nor cost effective.

- Deep ploughing (920 mm) and deep subsoiling (750 mm) have been compared with conventional tillage. Yields from the rainfed plant and first ratoon crops indicated that, in general, there was little advantage in ploughing or subsoiling to depths greater than 200 to 250 mm. The conclusion was that the extra expense of deep tillage is not warranted unless specific soil problems exist, such as compacted layers at depth.
- With conventional land preparation there is no need to prepare tilth to depths greater than 150 mm. The ease with which a good tilth may be obtained, and therefore the timing of the operation, is to a large extent dependent on soil type. For example, good tilth is not easy to achieve in the black and red structured clays. These soils have a plastic consistency when wet and a hard cloddy consistency when dry and can only be satisfactorily worked over a narrow moisture range, usually in spring under rainfed conditions. However, the consistency of the brown humic soil group is not as sensitive to moisture change and they can be worked virtually at any time of the year. The final tilth preparation should be done only a day or two before planting.
- Where a minimum tiller implement or the 'La Mercy toolbar' is used to prepare a banded seedbed, a good tilth is generally easier to obtain as the soil has not been disturbed and does not dry out as quickly as it does when conventional land preparation is used.
- A knowledge of soils is particularly important in deciding on the timing of seedbed preparation, as shown in Table 4.

Table 4. Timing and ease of soil tilth preparation of various soil groups

Soil group and management unit	Representative soil forms	Soil consistency	Ability to obtain good tilth	Timing of seedbed preparation
BROWN HUMIC (BHcms)	Inanda, Nomanci, Kranskop, Magwa, Lusiki, Sweetwater	Soft when wet, friable when dry	Easy	Virtually any time of the year
BLACK AND RED STRUCTURED (Bcms, Rcms)	Shortlands, Arcadia, Rensburg, Bonheim, Inhoek, Milkwood, Mayo, Willowbrook	Plastic when wet to very cloddy when dry	Difficult	Usually in spring under rainfed conditions
RED AND YELLOW-BROWN (Rcms, Bcms)	Augrabies, Bainsvlei, Hutton, Clovelly, Griffin	Soft when wet, friable when dry	Easy	Virtually any time of the year
GREY UPLAND (Gc, Gms)	Cartref, Glenrosa, Mispah, Oakleaf	Soft when wet, friable when dry	Easy	Early spring before the first rain to minimise the effect of soil compaction
GREY BOTTOMLAND (Gfs)	Tukulu, Klapmuts, Vilafontes, Longlands, Westleigh, Swartland, Valsrivier, Sepane, Kroonstad	Soft to slightly plastic when wet, cemented when dry	Moderately easy	Early spring before the first rain to minimise the effect of soil compaction
GREY DEEP, LOW CLAY (Gr)	Fernwood, Namib, Dundee	Soft when wet, friable when dry	Easy	Spring and summer due to the low water retention capacity

TRASH MANAGEMENT

- Trash conservation is a very effective means of reducing soil and water losses from sugarcane fields. This is particularly important in KwaZulu-Natal, where slopes are often steep and many of the soil types are highly erodible.
- Most soils occurring below about 500 m altitude, other than those in valley bottoms, irrigation blocks and where rainfall exceeds about 1100 mm, should not be burnt at harvest and the trash should be evenly spread as a trash blanket. This will increase cane yield, by reducing evaporation and maintaining a high rate of infiltration.
- Trashing is particularly important on shallow erodible soils and on steep slopes. Where the cane is not trashed, the burnt tops should be evenly scattered over the field after harvest except during winter at high altitude.
- Apart from benefitting from a possible 5 to 10 tc/ha yield response, trashing has also been found to reduce the need for chemical weed control, improve soil fertility through increased organic matter, N mineralisation potential, cation exchange capacity, and soil faunal and microbial activity.
- Some disadvantages of trashing include: increased volatilisation losses of N where urea is applied onto a trash blanket, lower soil temperatures which limit this practice at high altitude in winter, and severely stressed cane infested with the stalk borer eldana may not ratoon through a trash blanket.

Soil type is an important factor in determining whether or not to trash, and recommended guidelines are given in Table 5.

Table 5. Priority rating for trashing according to soil group

Soil group	Soil management unit	Erosion hazard	Other limitations	Priority for trashing
BROWN HUMIC	BHcms	Low	P fixation	Moderate Summer harvest
BLACK AND RED BLOCKY CLAYS	Bcms, Rcms	Low	Low capillary conductivity High wilting point	Moderate to high
	Bv		Low temperature	Low
RED AND YELLOW LOAMS TO CLAYS	Rcms, Yms	Low	P fixation	Moderate
GREY SANDY LOAMS	Gc, Gms, Gr	High	Surface crusting Low organic matter	High
	Gfs, Gv	Moderate	Surface crusting	Low

PESTS

- Although **parasitic nematodes** are found in all sugar industry soils, they cause serious damage to cane roots mainly in the weak sandy soils. As a guide, any soil which contains less than about 10% clay is likely to harbour parasitic nematodes which will cause loss of cane yield. As the clay content declines, the probability of response to treatment with nematicide increases.
- It is known that stressed cane is particularly vulnerable to infestation by **eldana borer**. Surveys conducted in various parts of the industry have shown that a higher incidence of stalk damage due to eldana occurs on light textured shallow grey soils derived from Vryheid sediments, Dwyka tillite and Natal Group Sandstone. Knowing the soils which are prone to moisture stress will be of value in helping to predict which areas are likely to need priority in treating for eldana (i.e. short cutting cycles, pre-trashing).
- Past surveys of cane damaged by **white grub** have shown that soils with a high organic matter content are particularly prone to infestation from this pest, but it is widely distributed over a range of soils.
- Soils can act as a guide to predicting the likelihood of damage from eldana, nematodes and white grub.

HERBICIDES

- The amounts of surface applied herbicides to be used depends on soil factors such as clay content, organic matter, pH and cation exchange capacity (CEC).

- Herbicides should be used at the higher recommended rates on brown humic soils, and on red and black clay loams, while lower rates should be used on loamy sands and sandy loams of the red and grey soil groups.
- Before using any herbicide, growers must **READ THE PRODUCT LABEL** with regard to the appropriate rate of application relative to soil clay percentage and organic matter. Also for any details referring to pH and CEC.
- Additional information regarding application rates for the wide range of herbicides used in the sugar industry may be found in the SASEX Herbicide Guide, which is updated annually.

FERTILISER MANAGEMENT

- Although soil analyses are essential for determining the optimum nutrient requirements of the cane crop, a knowledge of the soil can assist the grower in predicting losses of N due to leaching and denitrification, P and K fixation, Ca and Mg deficiency, Al toxicity and Zn deficiency .
- Results of extensive laboratory studies and fertiliser trials have shown that the nitrogen requirements of cane can be reliably estimated from a knowledge of the soil form and the organic matter content of the soil. Soils have been classified into four categories (low, medium, high and very high) according to their potential to mineralise nitrogen from organic matter in the soil, for use by the crop. In general, soil forms within the brown humic group have the greatest capacity to mineralise N, followed by the red and yellow soils, black clays and grey group of soils. It follows that cane growing on the brown humic soils requires the least amount of fertiliser N whereas cane growing on the grey soils requires the highest recommended rates.
- The sulphur requirement of cane closely follows that for nitrogen.
- Only soils that fall within the brown humic and red and yellow groups are likely to require lime and gypsum to correct a possible Al toxicity problem which can only be positively identified by soil analysis. On the other hand, lime may be needed in some soils of the grey group to correct deficiencies of calcium and magnesium.
- Clay soils in the brown humic and red and yellow groups also have the potential to fix large amounts of P, which will necessitate an above average P fertiliser requirement .
- Sandy soils falling in the grey and red and yellow groups are inherently low in potassium and will always need to be fertilised with between 175 to 200 kg/ha of K.
- The red and black cracking clay soils found in Mpumalanga are frequently associated with a high Ca+Mg to K ratio which necessitates above average amounts of K fertiliser for cane growing on a winter cycle.
- Cane growing in any of the soils of the brown humic group is very prone to zinc deficiency.

A guide showing the nutritional requirements of cane based on the different soil groups is given in Table 6.

ORGANIC MANURES

- Organic manures such as filtercake and poultry manure are very much under-utilised in the sugar industry. Traditionally their main benefit has always been regarded as a source of phosphorus, and the results of past research revealed that the most worthwhile growth responses were obtained on high P fixing soils of the Inanda and Hutton forms.
- The results of recent research have shown that decomposed filtercake can also act as a very effective conditioner of hard-setting duplex soils and shallow grey soils. Trials have shown that vertical mulching with filtercake to a depth of 450 mm in the planting row following minimum tillage, results in significantly higher yields and an increased number of ratoon crops.
- The main benefit appears to be the effect of the organic matter in filtercake binding soil particles.This has led to a great improvement in the infiltration rate, improved moisture holding capacity and cation exchange capacity, and an increased potential for nitrogen release, lower soil bulk density and increased rooting depth.
- In saline/sodic soil conditions, incorporation of filtercake at a rate of 350 tons/ha to a depth of 300 mm has been used successfully for reclamation purposes.
- The residual effects of buried filtercake last considerably longer than filtercake applied to the soil surface.
- Filtercake can also be used on all soils for winter and early spring planting, its high moisture content (±70%) protecting seedcane from desiccation if the rains are late. The filtercake envelops the cane setts and reduces air pockets in seedbeds with poor tilth, and its decomposition increases soil temperatures.
- A knowledge of soil can also assist the grower in deciding where best to apply filtercake or poultry manure, as shown in Table 7.

Table 6. Guide to the nutritional requirement of sugarcane based on soil groups

Soil group	Soil unit	Limitations	Fertiliser requirements	Management tips
BROWN HUMIC LOAMS	BHcms BHfs	High N mineralisation. Low K, Ca, Mg, Zn. Low P and high P fixation. High risk of Al toxicity.	No N for Champagne form. Rest 60 kg N/ha at plant and 100 kg N/ha to ratoons. P and K to every crop. Zn often required. Additional P often needed.	Regular soil and leaf sampling essential. Lime to be incorporated several weeks before planting. Filtercake or poultry manure beneficial.
BLACK BLOCKY CLAYS	Bcms	Moderate N mineralisation. Generally well supplied with P, K, Ca, Mg and Zn. In winter risk of K fixation increases.	Rainfed cane 100 kg N/ha at plant and 140 kg N/ha to ratoons; add 20 kg N/ha for irrigated cane. K requirement varies in relation to clay content.	Winter cycle cane, time urea for late August; LAN may be applied earlier. Summer cycle apply N within 4 weeks of harvest. With trash use LAN. Use gypsum with sodium accumulation.
	Bfs	Denitrification and salinity hazard.	For Bfs soils, 30/70 N splitting for winter cycle and 50/50 for summer cycle at 5-6 week intervals.	
RED AND YELLOW LOAMY SANDS TO CLAYS	Rcms Yms Rfs Yfs	Moderate to high N and S mineralisation. Ca and Mg well supplied. K and Zn moderate to high. In Midlands risk of Al toxicity and P fixation.	80 kg N/ha at planting. 120 kg N/ha ratoons 1 to 4. 140 kg N/ha ratoon 5+. Add 20 kg N/ha for irrigated cane. P and K to every crop. N fertiliser management as for Bfs soils.	In Midlands lime to be incorporated several weeks before planting. For lowveld irrigation of Rfs soils, 30/70 N splitting for winter cycle and 50/50 for summer cycle at 5 to 6 week intervals.
GREY SANDS TO SANDY CLAY LOAMS	Gc Gms	Low to moderate N mineralisation. Low to moderate P, K, Ca, Mg and S reserves.	120 kg N/ha at planting. 140-160 kg N/ha ratoons. K to every crop. Regular lime dressings. Add 20 kg N/ha for irrigated cane.	Regular soil and leaf sampling very important. Incorporation of lime at planting preferred. Under minimum tillage add lime to the penultimate ratoon crop. With eldana reduce N by 20 kg/ha. Split N and K applications advised for Gfs, Gv and Gr soils. Because lime can reduce the efficacy of Temik at planting, it should preferably be applied to the penultimate ratoon crop.
	Gfs Gv	Low to moderate N mineralisation. Low to moderate P, K, Ca, Mg and S reserves. Marked denitrification. Salinity/sodicity hazard.	120 kg N/ha at plant. 140-160 kg N/ha ratoons. Add 20 kg N/ha for irrigated cane. Apply K to most crops. Amelioration with gypsum may be necessary.	
	Gr	Low P, K, Ca, Mg and S. Leaching of N and K (Oakleaf and Dundee forms).	90 kg N/ha at plant. 130 kg N/ha ratoons. K to every crop.	

Table 7. Recommendations for the use of filtercake and poultry manure for different soil groups

Soil group	Terrain and management unit	Representative soil forms	Requirements and reasons
BROWN HUMIC AND ORGANIC	Inland plateaux (BHc)	Inanda, Kranskop, Lusiki, Sweetwater, Magwa, Nomanci	In P deficient and/or high P fixing soils, apply 30-40 t/ha filtercake or 5-8 tons poultry manure in the furrow at planting. If broadcast, twice in-furrow rate will be required.
BLACK	Crest to lower slope (Bcms)	Arcadia, Bonheim, Inhoek, Mayo, Milkwood	Where heavy clay soils with cloddy tilth are encountered, planting with 20-30 t/ha filtercake in furrow will be beneficial, as it envelops cane setts and reduces air pockets in the seedbed.
	Bottomland (Bv)	Rensburg, Willowbrook	Salinity/sodicity hazard likely in both soil forms. Add filtercake.
RED AND YELLOW-BROWN	Well drained (Rcms, Yms)	Augrabies, Bainsvlei, Hutton, Oakleaf, Clovelly, Griffin	In Midlands soils with low P status and virgin soils, apply 30-40 t/ha filtercake or 5-8 tons poultry manure in the furrow at planting. If broadcast, about twice the in-furrow rate will be required.
		Shortlands	To improve tilth of cloddy soils, apply 20-30 t/ha filtercake in the furrow at planting.
	Moderately drained (Rfs, Yfs)	Avalon, Bloemdal, Constantia, Pinedene	For P deficient and/or high P fixing soils, apply 30-40 t/ha filtercake or 5-8 tons poultry manure in the furrow at planting.
GREY	Crest to midslope (Gc, Gms)	Glenrosa, Cartref	Vertical mulching to a depth of 400 mm with 100 t/ha filtercake will increase yields, water infiltration rate and rooting depth.
	Lower slope to bottomland (Gv, Gfs)	Estcourt, Klapmuts, Vilafontes, Longlands, Oakleaf, Valsrivier, Westleigh, Katspruit, Kroonstad	Salinity/sodicity hazard. Instead of gypsum, filtercake at 350 t/ha can be incorporated to a depth of 300 mm in sodic soils for reclamation purposes.

HARVESTING

Mechanised harvesting and haulage systems are increasing in importance in the South African sugar industry, and these systems will have a greater impact on the soil at the time of harvest compared with the traditional manual system, particularly when harvesting occurs under wet conditions and there is a danger of infield traffic causing soil compaction.

- Research has shown that the tendency for soils to become compacted is greatest when their moisture content is near field capacity, particularly in the case of soils with a narrow particle size range (high fine sand and silt fractions).
- The grey bottomland soils (mainly Longlands, Katspruit and Kroonstad forms) and some of the black soils (Bonheim and Rensburg forms) are more sensitive to compaction in the wet state than those of the red and brown humic soil groups.
- Soil compaction or damage to stools will be less on free draining soils.
- Infield traffic under moist conditions causes smearing, capping and physical damage to cane stools. Large reductions in yields of sugarcane have been shown to occur where the wheels of infield transport run over the cane lines.
- Cane growing in compactible soils, where possible, should be harvested only under dry conditions.
- Some fields with free draining soils which are unlikely to compact severely should always be held in reserve for harvesting during wet periods.
- Tractors and trailers should be matched to each other and to the requirements of soil and terrain.
- Weight transfer linkages should be used to put more weight on the rear wheels of the tractor rather than the trailer.
- Match infield haulage equipment wheel spacing with cane row spacing so that trailer wheels run on the interrow and not on the cane row.
- Use large diameter wheels and high flotation tyres.
- Improve irrigation scheduling to allow for adequate soil drying.
- Rip the interrow only if there is definite evidence that the soil is compacted, a situation which is more likely to develop under wet conditions.

A suggested harvest programme based on soil groups is shown in Table 8.

Table 8. Suggested harvesting of main soil groups

Soil group and management unit	Soil form	Drainage	Soil compaction hazard	Timing of harvest operations
BROWN HUMIC (BHcms)	Inanda, Nomanci, Kranskop, Magwa, Lusiki, Sweetwater	Good	Low	Virtually any time of the year
BLACK AND RED STRUCTURED (Bcms, Rcms)	Shortlands, Arcadia, Rensburg, Bonheim, Inhoek, Milkwood, Mayo, Willowbrook	Moderate to poor	Moderate	Winter/spring
RED AND YELLOW-BROWN (Rcms, Yms)	Augrabies, Bainsvlei, Hutton, Clovelly, Griffin	Good	Moderate to low	Virtually any time of the year
GREY UPLAND (Gc, Gms)	Cartref, Glenrosa	Good	Moderate	Summer
GREY BOTTOMLAND (Gfs)	Estcourt, Klapmuts, Vilafontes, Longlands, Westleigh, Swartland, Valsrivier, Sepane, Kroonstad, Tukulu	Moderate to poor	Severe	Winter/spring
GREY DEEP, LOW CLAY (Gr)	Fernwood, Namib, Dundee, Oakleaf	Good	Low	Summer

IRRIGATION MANAGEMENT

Irrigation practices depend on a knowledge of soils. Soil type should influence:

- choice of irrigation system (e.g. sprinklers versus surface)
- water application rates
- frequency of irrigation cycles
- the quality of water that can be used
- gypsum requirement
- drying-off programmes.

- Good estimates of total available water (TAW) are necessary when deciding on the design of an irrigation system and determining cycle times and precipitation rates. The cheaper in-furrow system is not suitable where soils have a low TAW (e.g. Glenrosa, Swartland) or very high intake rate (Fernwood and some Dundee soils). Furrow irrigation is most effective in soils with a deep profile, a moderate to high TAW, and with either low or moderate intake rates (Shortlands, Hutton, deep Arcadia, Oakleaf).
- Overhead sprinkler irrigation can be used successfully on the majority of soils but, where the TAW is low and where a very short cycle time is needed (3 to 5 days in summer for the Fernwood or Glenrosa forms), subsurface or drip irrigation may be preferred. The suitability of soils, and systems recommended for irrigation, are summarised in Table 9.
- Before an irrigated crop is harvested it may be subjected to a period of drying off, but this should not be severe when chemical ripeners are used. In the absence of chemical ripeners the length of drying off depends on soil type. A deep Hutton soil with a TAW of about 200 mm must be dried off for 8 to 10 weeks in winter and 4 to 5 weeks in summer, whereas a Glenrosa form soil with a TAW of about 50 mm needs proportionally less time.

ENVIRONMENTAL MANAGEMENT

The South African sugar industry is sometimes described as 'a green desert – mountains of monotonous monoculture lacking adequate biodiversity'. Whether this criticism is justified or not, the bottom line is: ***can the industry sustain productivity and profitability in perpetuity?*** To this end, cane growers should heed environmental criticism and manage their cane production so that:

- soil loss by erosion is slower than the natural rate of soil regeneration.
- hydromorphic or wetland soils, such as the Katspruit and Kroonstad forms on streambanks, are allowed to revert to natural wetland vegetation, to enable flood water to be filtered and purified.
- riparian strips adjacent to water courses are left to natural vegetation (either grassland or riverine forest, but free of alien weeds) to increase biodiversity and create corridors of natural habitat for the movement and protection of birds and animals.
- existing gullies and abandoned quarries are re-vegetated.
- controlled cane fires are only undertaken within the accepted industrial code of burning practice, and adequate provision is made to fight and control wild fires.
- pollutants such as toxic agricultural chemicals, excess fertiliser and human waste are not allowed to enter water courses or be blown about by wind.

Monocropping may well be harmful to the long term health and productivity of sugar industry soils, but sugarcane, being a perennial grass, is far less likely to be part of this problem when compared with other annual crops.

CONCLUSION

- Agronomic practices are likely to become more varied as our knowledge of soil increases. If soils are adequately conserved and their management is appropriate, productivity and profitability should increase.
- A soil survey will greatly assist a grower in identifying the soils for each field on the farm. Once the grower knows the nature and distribution of soils, consideration can be given to changing boundaries in order to create fields with more uniform characteristics.
- The grouping of soils into the soil management units as presented in this section of the Soils Bulletin will facilitate an easier progression towards implementing site specific management principles.

Table 9. Suitability of main soil groups for irrigation and recommended systems

Soil group	Soil management units (SMU)	Representative soil forms	Steady intake rate	Drainage	Salinity/ sodicity hazard	Irrigation suitability	Recommended system	Other management needs
BROWN HUMIC LOAMS	BHcms	Nomanci Inanda Magwa	Fast	Good	Absent	Good	Drip Overhead Centre pivot	Moderate to long cycles
	BHfs	Sweetwater			Low			
BLACK BLOCKY CLAYS	Bcms	Mayo Milkwood Arcadia	Moderate to slow	Moderate to poor	Moderate to high	Moderate	Flood on gentle gradients Overhead Drip	Moderate cycle; drainage may be needed in some cases
	Bfs	Bonheim Inhoek	Slow					
	Bv	Willowbrook Rensburg	Slow to very slow	Very poor	High to very high	Unsuitable (except under drip)	Drip, but these soils preferably not for irrigation	
RED AND YELLOW LOAMY SANDS TO CLAYS	Rcms	Hutton Oakleaf (red)	Fast to moderate	Good	Low	Very good	Overhead Centre pivot Drip	High TAW; favours long cycles
	Yms	Shortlands Clovelly	Moderate		Moderate to low	Good	Drip Overhead Centre pivot	
	Rfs	Griffin Bainsvlei		Moderate		Moderate to good		
	Yfs	Bloemdal Avalon						
GREY SANDS TO SANDY LOAMS	Gc	Glenrosa	Moderate	Moderate to good	Low	Moderate to poor	Drip Overhead Centre pivot	Short cycles
	Gms	Cartref Oakleaf						Low TAW
	Gr	Swartland Oakleaf Vilafontes Tukulu Namib		Moderate to poor	Moderate			Short cycles for most of these soils
	Gfs	Fernwood Dundee	Fast	Excessive	Low	Moderate	Drip Overhead	
	Gv	Longlands Westleigh Estcourt Kroonstad Katspruit	Slow to very slow	Poor	High to very high	Unsuitable (except under drip)	Drip, but these soils preferably not for irrigation	Specialist advice required as drainage and gypsum may be needed

APPENDIX 1
SOIL PARENT MATERIALS IN THE SOUTH AFRICAN SUGAR INDUSTRY

Swaziland basic rocks

- Part of the basal complex (over 2 000 million years old).
- Mostly metamorphic rocks – highly mineralised and found in Mpumalanga and Swaziland.
- Forms neutral to alkaline blocky clays, often stony.

Amphibolite

- Part of the basal complex – old metamorphic rock in close association with granite.
- Rich in clay forming minerals.
- Forms highly fertile black or dark coloured blocky clays.

Pre-granite quartzite

- Part of the basal complex occurring as small isolated patches in association with granite.
- Extremely hard and resistant to weathering.
- Usually forms shallow, rather infertile, grey coarse grained sandy loams.

Tugela schist

- Metamorphic rocks – nearly as old as granite and often associated with it.
- Produce heavy red or black clay soils mainly in Zululand. Often show a stone line of quartz fragments in soil profile.

Granite

- The most common component of the basal complex (600 to 2 000 million years old).
- Acid igneous granites – found (i) steep country near sea, KwaZulu-Natal south coast, (ii) Valley of a Thousand Hills to Mapumulo, (iii) Tugela valley below Kranskop, (iv) parts of Zululand, Swaziland, Mpumalanga.
- Granites in humid coastal climate – form deep, abrasive, highly erodible coarse grained sandy to sandy clay soils on steep younger surfaces.

Natal Group Sandstone (NGS)

- Lies on top of old granite and schists (known previously as Table Mountain Sandstone).
- Oldest sedimentary rocks formed by erosion of the basal complex (400 to 600 million years old).
- Forms hard base of many flat topped plateaux in KwaZulu-Natal from Transkei in the south to Melmoth in the north.
- Forms abrasive, medium grained shallow grey sandy soils on steep/young surfaces.
- Forms deep, well drained red soils on older surfaces.
- Often forms dark brown humic topsoils overlying well drained red or yellow subsoils on very old surfaces.

Dwyka tillite

- Occurs on top of NGS (350 million years old).
- Sediments laid down by receding glaciers which left behind mud, boulders and rock fragments.
- Weathers slowly and ultimately forms shallow, fine grained sandy clay loams.
- Dwyka derived soils have higher silt content than most other South African soils, with high bulk density and low infiltration rate – cement hard when dry and like slurry when wet.

Pietermaritzburg shales

- Overlie Dwyka tillite – sedimentary and previously called Lower Ecca shales (300 million years old).
- Comprise fine grained, dark hard rocks made up of flat plates or closely packed layers.
- Weather slowly to form dark black, shallow blocky clays.

Vryheid sediments

- Previously called Middle Ecca sediments and formed in shallow water, in marshes or river mouths (250 million years old).
- Very variable and may contain fossil or coal deposits.
- Form shallow loamy soils.

Tarkastad sediments

- Very variable sedimentary rocks previously known as Beaufort sediments (150 to 180 million years old).
- Unimportant parent material in the sugar belt but widespread further inland.
- Occur in the Heatonville area – form poor erodible soils.

Clarens sandstone

- Wind blown origin with characteristic cross bedding – previously known as Cave sandstone (140 to 150 million years old).
- Unimportant parent material in the sugar belt but occurs at Heatonville and Komatipoort.
- Very resistant to weathering – gives rise to shallow medium grained sands.

Dolerite - basalt - diabase

- Fine grained basic igneous rocks (±130 million years old).
- Dolerite occurs as dykes, pipes or sills within older sedimentary rock, while basalt once occurred at the surface as thick sheets of molten lava (5 000 m thick in Drakensberg).
- On young surfaces soils are usually black clays with marked swell/shrink properties (montmorillonitic clays).
- On older surfaces soils are more mature with illitic and kaolinitic clays dominating – usually red due to presence of iron.

Cretaceous sediments

- Soft rocks rich in calcium fossils from crustacea (50 million years old).
- Give rise to grey, friable, medium textured soils, rich in calcium and magnesium.

Recent Sands

- Laid down under the Indian Ocean and first exposed about two million years ago – younger than cretaceous sediments.
- Give rise to deep, light textured soils.
- Red sands – red ferric iron surrounds each grain, giving friable apedal structure.
- Grey sands – grey either due to wind erosion which removed red iron coating, or reduction of ferric iron in valley bottoms.

Alluvium

- Found on flood plains and of recent origin.
- Very variable in colour, texture and grain size.
- Every flood deposits a new layer of sediment on the surface.
- Often mottled at depth and rich in organic matter.

Extent of soil parent materials in the South African sugar industry

Soil parent material	Map colour guide	Percentage distribution of total area surveyed						
		Overall	South Coast	Midlands	North Coast	Zululand	Pongola	Mpumalanga
Swaziland basic rocks	Red hatched	0,65	–	–	–	–	–	0,65
Amphibolite	Red cross-hatched	0,21	0,21	–	–	–	–	–
Pre-granite quartzite	Red dotted	0,07	0,03	–	–	0,04	–	–
Tugela schist	Red hatched	2,31	0,73	0,16	0,15	1,25	0,02	–
Granite	Red	9,62	7,54	0,19	0,36	1,19	–	0,34
Natal Group Sandstone (NGS) (Mistbelt)	Blue with white dots	4,96	0,71	1,37	2,74	0,14	–	–
Natal Group Sandstone (NGS) (Ordinary)	Blue	24,90	7,10	8,76	7,59	1,45	–	–
Dwyka tillite	Red-brown	9,35	3,68	1,89	3,29	0,50	–	–
Pietermaritzburg shales	Dark brown	6,19	0,98	1,86	2,42	0,93	–	–
Vryheid sediments (sandstones and shales)	Yellow-brown	6,62	0,03	1,30	1,67	3,22	0,40	–
Tarkastad sediments	Grey	2,01	–	–	–	2,01	–	–
Clarens sandstone	Pink	0,06	–	–	–	0,06	–	–
Dolerite - basalt - diabase	Light green	12,22	0,72	4,89	2,69	3,19	0,26	0,47
Cretaceous sediments	Yellow hatched	0,29	–	–		0,29	–	–
Recent Sands - Red	Orange	4,58	0,28	–	1,66	2,64	–	–
Recent Sands - Grey	Yellow	5,61	0,32	–	0,89	4,40	–	–
Alluvium	Dark green	10,41	0,53	3,51	1,29	4,05	0,83	0,21
	Total	100,00	22,86	23,93	24,75	25,36	1,51	1,67

Note: The area under cane in the South African sugar industry was about 422 000 hectares in 1998. Total area surveyed was 587 865 hectares.

APPENDIX 2
SOIL SYSTEMS IN THE SUGAR BELT

Coastal Sands System (formerly Berea System)

- Includes all Recent Sands and soil derived from Cretaceous sediments raised above sea level two million years ago.
- Associated with a young land surface, which is wide in the north, and narrow and discontinuous in the south.
- Occurs at low altitude in a maritime climate.
- Many soils derived from wind-blown coastal dunes are less than 4 000 years old.

Coastal Lowlands System (formerly Umzinto Coast Lowlands)

- Area inland from coastal sands to ±300 metre altitude.
- Has strong maritime influence and mainly frost free.
- Soils shallow and less than 18 000 years old showing great variability as geologically complex.
- Strong pattern of ancient termitaria (iziduli) on lighter textured soils.

River Valley System (formerly Umzinto River Valleys)

- Areas are fragmented and include most deep river valleys of KwaZulu-Natal and Swaziland.
- Occur at altitudes of between 60 to 730 metres.
- Soils very young due to rapid recent geographical erosion.
- Mainly found in rain shadow areas.

Hinterland System (formerly Umzinto Midlands)

- Areas mainly between 300 and 950 metres altitude, with topography undulating to fairly steep.
- Occurs on an older land surface than the Coastal Lowlands System.
- Soils usually deeper but variable with strong iziduli pattern.
- Frost occurs in the west and at higher altitudes.

Mistbelt System (formerly Nottingham System)

- Soils very old and associated with the ancient African land surface.
- Climate cool and moist with mist and topography gentle.
- Soils uniform, even when associated with different parent materials.
- Many soils with thick or thin humic topsoils while subsoil often deeply weathered with apedal structure.

Dry Lowveld System (formerly Komatipoort System)

- Soils occur in low rainfall areas where evaporation exceeds precipitation and require irrigation to produce economic crops.
- On young land surfaces mainly below 380 m altitude.
- Soils mostly shallow, often stony, strongly structured and contain free lime.
- Occur on the same land surface as Coastal Lowlands System.

Humid Lowveld System (formerly Nelspruit System)

- Soils moderately weathered, mostly without free lime.
- Generally hilly and above 300 m altitude.
- Climate warm sub-humid.
- Soils somewhat older and deeper than in Dry Lowveld System, and stones in profile less numerous.

Note: All areas within the cane belt have been mapped on small scale maps (see pages 13 to 20). These maps are designed to give only an approximate distribution of the main Systems but, if topography and soil type are both observed carefully in the field, the accuracy and detail of the Systems Map can be greatly improved. Systems mapping is useful to describe a large group of soils that all developed under similar circumstances even though they may differ in parent materials and other characteristics.

APPENDIX 3
DESCRIBING AND RATING SOIL PHYSICAL PROPERTIES

Properties used to describe a particular soil horizon include:

Colour

The most important colours are black, dark grey, light grey, red, yellow, brown and blue. When describing the colour of an horizon it is important to state whether it has a single uniform colour, or whether it is variegated or mottled.

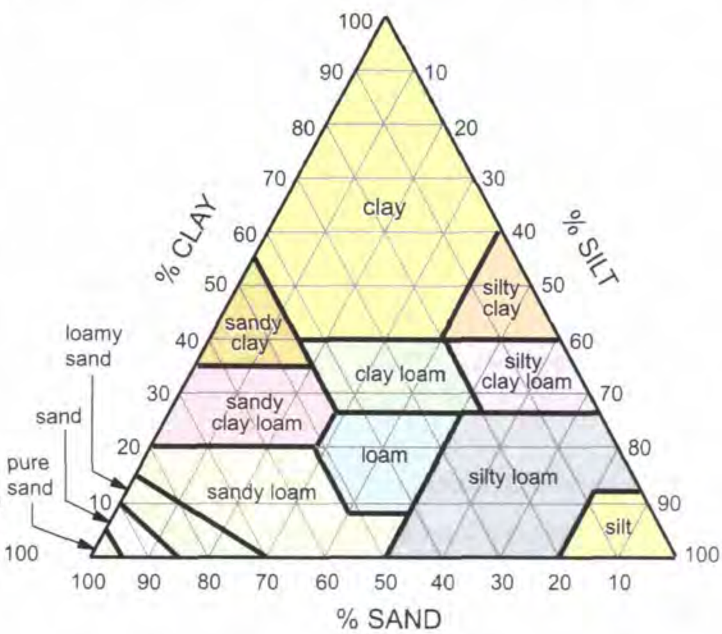
- Black and dark colours signify either the presence of organic matter or darkly coloured clay particles.
- Light greys or bleached colours indicate strongly eluviated horizons.
- Red and brown colours indicate well aerated and well drained conditions and are usually found in upland positions. The colour usually comes from the soil particles being coated with iron and aluminium oxides.
- Yellow and yellow-brown colours indicate somewhat less well drained, shallower profiles or dystrophic conditions. The colour usually comes from the soil particles being coated with hydrated iron and aluminium oxides.
- Grey and blue colours are associated mainly with poorly drained bottomlands, strong reduction reactions and waterlogging.
- Mottled colours usually indicate anaerobic or waterlogged conditions with strong reduction of iron and aluminium oxides.
- Variegated colours usually indicate presence of clayskins, different coloured minerals or recent soil weathering.
- Uniform colours indicate conditions that have persisted for a long time.

Texture

The texture of a soil is determined by the relative proportions of sand, silt and clay, with the grade of sand also being used as a criterion. Use of the textural triangles shown below enables soil texture to be accurately determined following a physical analysis of a soil in the laboratory.

coarse sand 2,0 to 0,5 mm
medium sand 0,5 to 0,25 mm
fine & very fine sand 0,25 to 0,05 mm

***SAND GRADE CHART**

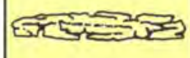


sand 2,0 to 0,05 mm
silt 0,05 to 0,002 mm
clay less than 0,002 mm

TEXTURE CHART

*Note: Values are expressed as percentages of the total sand, not the total soil.

In the field some idea of textural class can be determined by taking a handful of **moist** soil, kneading and rolling it between the palms of the hands to form a 'spindle' or 'sausage'. The diagram below illustrates this relationship.

If no sausage can be rolled, the soil is sandy (less than 10% clay)	No sausage	Sand
If a sausage can just be formed but it cracks upon bending, it is a loamy sand (10 to 15% clay)		Loamy sand
If it will bend a little, it is a sandy loam (15 to 20% clay)		Sandy loam
If it will bend readily before cracking, it is a sandy clay loam (20 to 35% clay)		Sandy clay loam
If it will bend around nearly into a circle, it is a sandy clay (35 to 55% clay)		Sandy clay
If it will bend into a circle, it is a clay (more than 55% clay)		Clay

Structure

- Refers to natural aggregation of primary soil particles into compound units or peds which are separated from one another by planes or surfaces of weakness.
- Cohesion within peds is greater than adhesion between them.
- Structured particles are categorised according to their nature (type, size and degree).

Type	:	angular, apedal, blocky, columnar, crumb, granular, platy, prismatic
Size	:	fine, medium, coarse
Degree	:	strong, moderate, weak, structureless.

- **Strongly structured soils** are those with spaces between clearly defined peds (**blocky** or **prismatic** structure).
- Blocks may vary in size from a few millimetres to 40 or 50 mm in cross section. Prisms are normally 30 to 60 mm across and at least 100 mm deep.
- In **weakly structured soils** it is difficult to see boundaries between peds, e.g. **apedal** is a non-visible structure but each grain is coated with a porous microscopic layer of hydrated iron and aluminium oxides.

Consistency

- Used to describe the physical state of a soil in relation to how it changes with moisture content and its effect on mechanical cultivation in particular.
- As moisture content changes from very dry to very wet, the following descriptive terms can be used for different conditions.

Moisture status:	Very dry	:	harsh, hard, cloddy, powdery
	↓	:	firm
	↓	:	friable, soft
	↓	:	plastic
	Very wet	:	sticky or saturated.

- Both texture and structure have a marked effect on soil consistency, e.g. sands need only little water to become soft, friable and easily worked, while clays need more.
- Strongly structured soils have to be worked when their moisture contents lie between close limits; often they are either too firm or sticky for cultivation.

Slickensides

- Polished or grooved surfaces within the soil resulting from its movement and occurring in cracking clay materials.
- Alternate shrinking and swelling caused by differences in moisture content result in the polished faces being formed.

The physical characteristics of the various soil families and series have been rated as follows:

Available water capacity (AWC)

Five ranges of available water capacity have been chosen:

very high	:	more than 180 mm/m	:	more than 55% clay
high	:	140 to 180 mm/m	:	35-55% clay
moderate	:	100 to 140 mm/m	:	15-35% clay
low	:	80 to 100 mm/m	:	6-15% clay
very low	:	less than 80 mm/m	:	less than 6% clay.

These AWC values correspond only approximately with the clay percentages shown above.

Steady intake rate

This is the rate at which water enters into a moist soil from above and is also known as the infiltration capacity. The rate will vary between and within soil forms. Three ranges have been chosen:

good	:	more than 13 mm/hour
medium	:	6 to 13 mm/hour
poor	:	less than 6 mm/hour.

Drainage

This term describes the ease with which water moves through the soil profile and is also referred to as internal drainage or permeability. Five categories of drainage have been chosen:

Category		Rate of water movement
excessive	:	more than 0,60 m/day
good	:	0,30 to 0,60 m/day
moderate	:	0,15 to 0,30 m/day
poor	:	0,05 to 0,15 m/day
very poor	:	less than 0,05 m/day.

NB. Accurate information on internal drainage is not available for the majority of soil forms, and the limits for the above ranges are tentative. However, a useful practical field test is to put five drops of water onto a fresh soil clod over five seconds. Then count the number of seconds it takes for the water to be absorbed.

The following scale provides a measure of the rate of internal drainage of a soil:

Range		Rate of internal drainage
excessive	:	less than 2 seconds
fast	:	2 to 5 seconds
good	:	5 to 10 seconds
poor	:	10 to 20 seconds
very poor	:	more than 20 seconds.

Erosion hazard

Is based on the soil erodibility nomograph developed by Wischmeier *et al* (1974). From this nomograph the Universal Soil Loss Equation K factor can be estimated for each soil in terms of texture, organic matter content, structure and permeability. For sugar industry soils, K ratings from very high to very low have been based on results from trials using runoff plots and the nomograph. The higher the silt plus very fine sand fraction, the more erodible a soil is likely to be. Also, the deeper the soil, the less severe erosion is likely to be.

Tillage constraints

The constraints range from slight to severe and the actual rating is determined by one or more of the following soil factors:

- **cloddy consistency (cl)** : soils in this category tend to be very slippery when wet and hard and cloddy when dry, making it extremely difficult to get a good tilth.
- **crusting and capping (cr)** : soils that crust tend to be soft and slightly plastic when wet and cemented and brittle when dry.
- **compaction (co)** : applies to soils that are prone to physical damage (puddling and smearing) by infield traffic under wet conditions.
- **machine wear (mw)** : refers to wear caused by abrasion in sharp sandy soils.
- **subsurface hindrance (sh)** : refers mainly to shallow soils on hard rock or plinthite.

Soil pH

This is the degree of acidity or alkalinity of a soil, measured with a pH electrode as –log[H^+]. All measurements are in water (1:1) unless indicated otherwise. The relationship between pH rating, soil reaction and measured pH is as follows:

pH rating	Soil reaction	pH (H_2O)
Very low	Extremely acid	Less than 4,0
Low	Strongly to moderately acid	4,0 to 5,5
Moderate	Moderately to slightly acid	5,5 to 7,0
High	Slightly to moderately alkaline	7,0 to 8,5
Very high	Strongly alkaline	More than 8,5

Soil pH has an important influence on soil chemistry, notably the availability of plant nutrients, as shown in Figure 1 below, where the widest parts of the shaded areas indicate maximum availability.

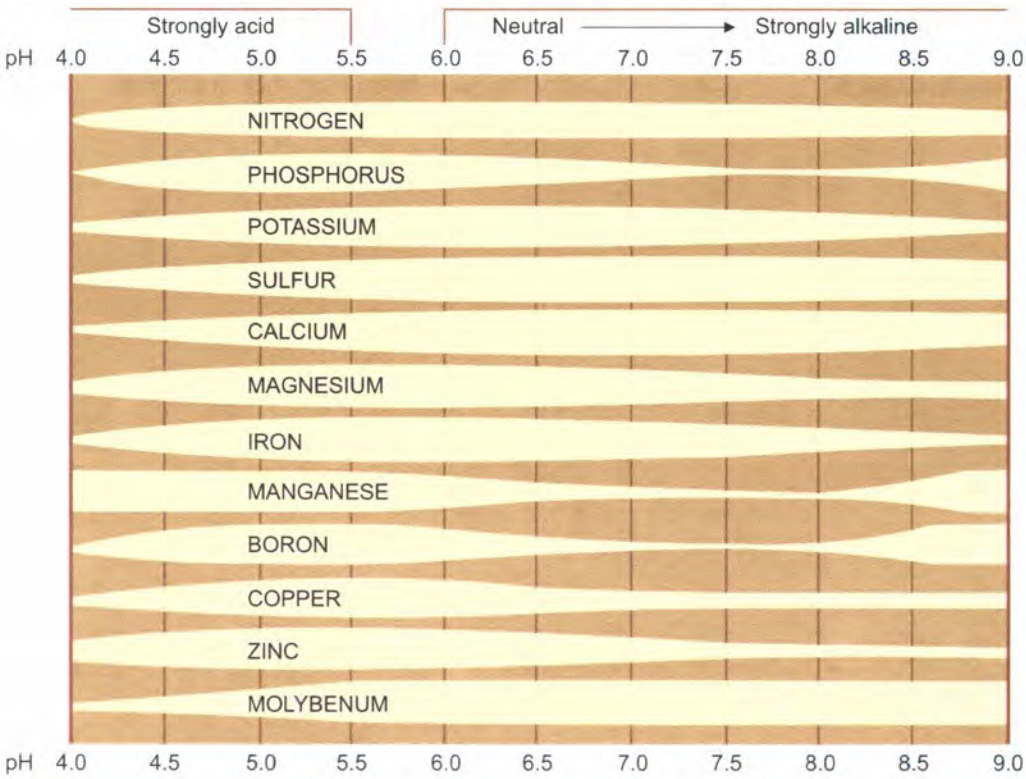


Figure 1. The relationship between pH and the availability of various plant nutrients

Base status

A qualitative expression (**low, moderate, high**) of base saturation (%). Base saturation is the sum of exchangeable Ca, Mg, Na and K expressed as a percentage of cation exchange capacity measured at a specified pH. Base status may be linked to the degree of leaching in soils as follows:

Base status	Degree of leaching	Sum of bases (me/100 g clay)
Low	Marked (dystrophic)	Less than 5
Moderate	Moderate (mesotrophic)	5 to 15
High	Negligible (eutrophic)	More than 15

Aluminium toxicity hazard

This refers to the harmful effect on cane growth due to toxic concentrations of exchangeable aluminium in acid soils (pH less than 5,3). Toxic concentrations of soil Al are best ameliorated with lime, based on the **aluminium saturation index (ASI)** measurement, which is the **percentage of cation exchange capacity occupied by exchangeable Al**. The interpretation of ratings is as follows:

Al toxicity	Interpretation	ASI (%)
Absent	No Al toxicity problem	Less than 5
Low	Unlikely to be a problem	5 to 10
Moderate	Concentrations of Al may be toxic to the most sensitive varieties	10 to 20
High	Likelihood of Al toxicity to most varieties except N12	20 to 40
Very high	Strong likelihood of Al toxicity to all varieties	More than 40

P fixation

This refers to the process by which soluble P fertilisers in the soil are converted (adsorbed, precipitated) into forms which are less available to plants. The **phosphate desorption index** (PDI; 0,0 to 1,0) measurement is used together with the Truog P extraction procedure to develop P fertiliser recommendations for sugarcane. The inverse relationships between P fixation ratings and PDI ranges are as follows:

<table>
<tr><th>P fixation</th><th>Interpretation</th><th>PDI</th></tr>
<tr><td>Very low</td><td>No supplementary P fertiliser is necessary</td><td>More than 0,4</td></tr>
<tr><td>Low</td><td rowspan="4">As P fixation increases from low to high, and PDI decreases from 0,4 to 0,1, the need for supplementary P fertiliser increases</td><td>0,3 to 0,4</td></tr>
<tr><td>Moderate</td><td>0,2 to 0,3</td></tr>
<tr><td>High</td><td>0,1 to 0,2</td></tr>
<tr><td>Very high</td><td>Less than 0,1</td></tr>
</table>

K reserves

Marked differences occur between soil forms in their capacity to supply both exchangeable and non-exchangeable K to growing plants. Soils have been classified into **low, moderate or high K categories**, based on clay content and location.

Trace element availability

These are specified where necessary as **low, moderate or high**, depending on their behaviour with pH (see Figure 1). In general, the metal elements (manganese [Mn], iron [Fe], copper [Cu], zinc [Zn]) and boron [B] are less available at alkaline pH, while molybdenum [Mo] availability is inversely affected.

Organic matter

Soil organic matter is the organic fraction of soil ranging from undecayed fresh plant and animal tissues through ephemeral products of decomposition to fairly stable amorphous brown to black material, known as **humus**, which bears no trace of the original material from which it was derived. Due to its strong influence on soil chemistry (CEC, N+S mineralisation, P fixation, pH), soil organic matter concentration (%) is measured in the laboratory and soils are classified into five categories: **very low (less than 1%)**, **low (1 to 2%)**, **moderate (2 to 4%)**, **high (4 to 6%)**, **very high (more than 6%)**.

N and S mineralisation

Organic forms of N and S in the soil may be transformed to inorganic forms by microbial decomposition. Major differences in **N mineralising capacity** exist between soil forms and series, which may affect their N fertiliser requirements. Soil forms are classified into four categories of N and S mineralising capacity, based on their organic matter content as shown in the following table:

N and S mineralising rating	Soil forms	Mineralising category	Organic matter (%)
Low	Fernwood, Cartref (light), Longlands, Westleigh, Kroonstad, Katspruit, Glenrosa (light), Estcourt, Sterkspruit, Dundee, Shepstone, Mispah (grey), Oakleaf (light)	1	Less than 2
Moderate	Cartref (mod), Glenrosa (heavy), Clovelly (light), Hutton (light), Oakleaf (mod), Swartland, Bonheim (non-red), Valsrivier, Tambankulu, Willowbrook, Rensburg, Arcadia, Milkwood, Mayo, Inhoek, Mispah (brown), Longlands (mod)	2	2 to 3
High	Hutton (heavy, mod), Shortlands, Bonheim (red), Oakleaf (red), Glenrosa, Clovelly (mod), Griffin (mod)	3	3 to 4
Very high	Champagne, Inanda, Nomanci, Kranskop, Magwa, Lusiki, Sweetwater	4	More than 4

Salinity/sodicity hazard

Salinity is the measure of total soluble salts in the soil solution, which may negatively impact on sugarcane growth. No precise interpretation of the salinity measured as **electrical conductivity (EC)** of the **soil saturation extract** is possible, since the added effects of irrigation water, drainage, soil texture and cane variety are all important. However, **EC** values above 200 mS/m are likely to affect cane growth as follows:

Salinity rating	Interpretation / detrimental effects on cane growth	EC (mS/m)
Low	Non-saline / none	Less than 200
Moderate	Slightly saline / slight	200 to 400
High	Moderately saline / severe	400 to 600
Very high	Strongly saline / very severe	More than 600

The mean sodium adsorption ratio (SAR) of the soil saturation extract (proportion of Na to Ca+Mg) is used as an index of **sodicity**. Different soil forms vary in their sensitivity to Na and on this basis are assigned critical SAR values as follows:

Rating	Forms	Interpretation	Critical SAR
Low	Champagne, Inanda, Cartref, Clovelly, Dundee, Fernwood, Griffin, Hutton, Oakleaf, Shepstone, Shortlands	Generally well drained, non-dispersive soils associated with Recent Sands and other parent materials in upland positions	15
Moderate	Arcadia, Rensburg, Bonheim, Mayo, Milkwood, Tambankulu, Willowbrook	Mainly slowly draining black swelling clays associated with dolerite, Pietermaritzburg and Vryheid shales, Swaziland basic rocks and heavy alluvium	10
High	Estcourt, Glenrosa, Katspruit, Kroonstad, Londlands, Mispah, Swartland, Valsrivier, Wasbank, Westleigh	Generally poorly drained, highly dispersed grey soils derived mainly from Dwyka tillite, Vryheid and Tarkastad sediments and sandy alluvium	6

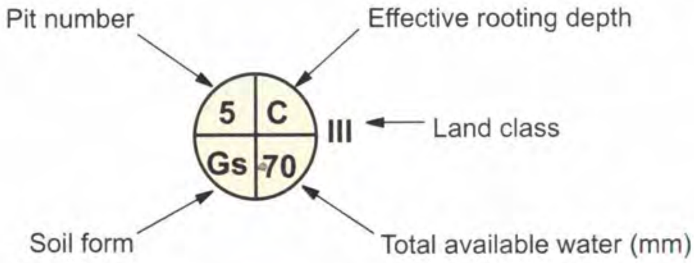
APPENDIX 5
SOIL SURVEYS, MAPPING AND LAND CLASSES

Without a knowledge of its soils, it is virtually impossible to assess a farm's full potential and manage it to best advantage. Soil surveys and maps do not only serve to identify and name soils but, together with land characteristics, they facilitate an understanding of their assets as well as their limitations. Various intensities of soil survey can be done, ranging from a simple reconnaissance to detailed mapping.

- In a reconnaissance survey, road cuttings and gullies are used to describe and identify various soil profiles. Rock outcrops confirm parent material and topsoil colour; texture and structure are also observed.
- In a semi-detailed survey, orthophotographs or aerial photographs are first studied to make a terrain appreciation. Then pit positions are sited on these in upland, midslope and bottomland situations to represent typical conditions. These positions are then identified in the field and exploratory soil pits are dug.
- A soil pit should be 1,2 m deep, or to the depth of a shallower impervious horizon.
- When detailed mapping is required, e.g. for irrigation purposes, soil pits are usually sited in the field using a grid pattern – say 200 x 200 m, or one pit to every four hectares. Pits are only moved away from the accurate grid positions to avoid hazards like roads, buildings or termite mounds.

The results of a soil survey can be mapped in various ways:

- The point system simply identifies the profile by carefully plotting its position on a map, in the shape of a circle, with its centre pinpointing the pit's position. The circle can be divided into segments depicting different information as required.



- In the boundary method, a line is drawn which is an estimate of the boundary between required mapping units.
- A combination of the two methods would provide the most information on the map.

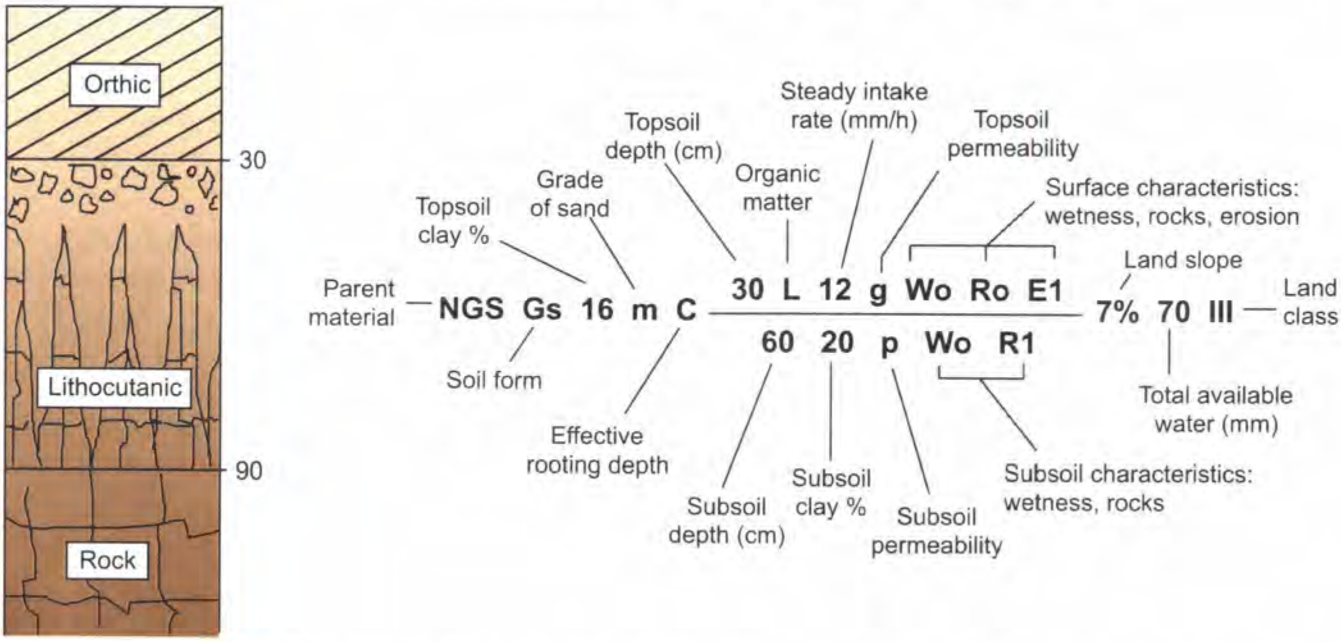
Soil profile descriptions are made either on pre-printed sheets, or the information can be recorded as a soil code. Below is an example of a pre-printed sheet.

Soil survey profile description

Job No.		Client			Farm name					Date			Surveyor			
Pit no.	Par mtl Form Series	Diagnostic horizon	Depth (cm)	Colour	Struc-ture	OM	Clay %	Grade of sand	Infiltrat/ permeab	Wet	Rock	Eros	Comp	Cap	ERD	TAW (mm)
1	NGS	Orthic A	30	G		L	15	m	12	Wo	Ro	E1	Ko	C2	C	55
	Cartref	E	50	LG			10	m	f	Wo	Ro		Ko			
	21	Litho	20	V	W		20	m	s	Wo	Ro		Ko			
2		A														
3		A														

Soil codes enable a considerable amount of observable information to be condensed into a small space. There are a number of different codes in use but the standardisation of a uniform code for the sugar industry would have obvious advantages. It should include sufficient detail, which may be needed for future decision making. It is often also useful to draw a small diagrammatic sketch of each soil pit for better visual appreciation.

The following suggested code has used many good features from existing codes and it is hoped that this new combination will fit the specific needs of the sugar industry (whether or not the crop is irrigated). However, both the codes and the profile description forms are flexible and can be changed to meet requirements.



- Parent material, soil form, topsoil clay percentage, grade of sand and effective rooting depth are the key issues, and are written first.
- Topsoil characteristics are coded above the line. Letters and numbers or capitals and lower case are used alternately to facilitate easy interpretation.
- Subsoil characteristics are coded below the line.
- Percentage land slope, which is not really a soil characteristic, is written at the end. An interpretation of all the characteristics gives the TAW and the land capability class.

The explanation of the code requires rather more space than the code itself but, once the user is familiar with it, it is easy to understand. The abbreviations of the possible symbols are as follows:

Parent material	abbreviations from Appendix 1 (page 152)
Soil form	standard abbreviations as shown on colour plates
Topsoil clay	percentage
Grade of sand	c = coarse, m = medium, f = fine
Effective rooting depth (ERD)	soil depth becomes less critical with increasing depth, therefore the following ranges have been suggested: A = more than 1 200 mm B = 800 to 1 200 mm C = 500 to 800 mm D = 300 to 500 mm E = less than 300 mm

Topsoil characteristics

Topsoil depth	in centimetres
Organic matter	L = low (less than 2%) M = moderate (2 to 4%) H = high (more than 4%)
Steady intake rate	millimetres per hour

Subsoil characteristics

Subsoil depth	in centimetres
Subsoil clay	percentage

Topsoil and subsoil permeability	e = excessive	(less than 2 seconds) (see Appendix 3, page 157)
	f = fast	(2 to 5 seconds)
	g = good	(5 to 10 seconds)
	p = poor	(10 to 20 seconds)
	v = very poor	(more than 20 seconds)
Topsoil and subsoil seasonal wetness	Wo = no wetness	
	W1 = short periods (weeks)	
	W2 = long periods (months)	
	W3 = almost year round	
Topsoil and subsoil rockiness	Ro = no rocks	
	R1 = few loose rocks	
	R2 = moderate hindrance	
	R3 = non-arable due to rocks	
Visible signs of erosion	Eo = no erosion	
	E1 = slight	
	E2 = moderate	
	E3 = severe	

Interpreting the code from the example on page 164, one could say:

- This is a very common soil, derived from Natal Group Sandstone, Glenrosa form, medium sandy loam and its effective rooting depth is between 50 and 80 cm.
- The orthic topsoil is 30 cm deep, with less than 2% organic matter, probably light grey in colour, 12 mm/hour steady intake rate and moderate to good permeability.
- There are no signs of wetness, some stones or rocks in the subsoil, and slight signs of erosion.
- The subsoil (lithocutanic B) is 60 cm deep, and has 20% clay in the soil tongues. The permeability of the subsoil is poor or slow.
- The soil pit is on a 7% slope, the total available water is about 70 mm and class III land has medium potential, fairly serious limitations and needs careful management and conservation.

Land capability classes interpret both soil and land characteristics. The following table is suggested especially for sugarcane cultivation:

Land capability classes

Criteria \ Class		I	II	III	IV	V	VI	VII
Clay percentage in topsoil		20 to 40* (1:1)**	15 to 20* or 40 to 50 (1:1)	10 to 15* or 50 to 55 (2:1)**	<10* or >55 (2:1)	–	>10	–
AWC (mm/m)	light soils heavy soils	120 to 160 120 to 160	110 to 140 110 to 140	90 to 120 110 to 130	70 to 100 100 to 120	– –	110 to 140 110 to 140	– –
Effective rooting depth (ERD) (mm)		>1 200	>800	>500	>300	–	>800	–
TAW (mm)	light soils heavy soils	>160 >160	>110 >110	>80 >80	>60 >60	– –	>110 >110	– –
Permeability	light soils heavy soils	good good	good good	fast poor	excessive very poor	– –	fast poor	– –
Wetness / Rockiness / Erosion		Wo Ro Eo	Wo Ro Eo	W1 R1 E1	W2 R2 E2	W3 – –	Wo R1 E1	– – –
Percentage land slope		<3	<6	<10	<15	–	<30	–

*Any topsoil that overlies an E horizon must be downgraded to the next class

**(1:1) and (2:1) refers to the type of clay mineral: 1:1 clays do not shrink and swell, while 2:1 clays do

Modifying the land class

If the soil characteristics appear to place a soil in a particular class (e.g. class III), but the land slope is one class steeper than its limit (say 10 to 15%), then the TAW must be one class better (more than 110 mm) to keep that land in the original class (i.e. class III). Similarly, if the land slope is two classes steeper than the soil criteria, then the land class need only drop one class. In other words, deep high potential soils on steep slopes will fall into a land class intermediate between the soil potential and that of the slope.

Utilisation of land capability classes with special reference to sugarcane

Classes I & II : high potential for both sugarcane and annual crops; few limitations; fairly easy to manage and conserve

Class III : medium potential for both sugarcane and annual crops; fairly serious limitations; needs careful management and conservation

Class IV : low potential; serious limitations; needs very good conservation practices and special management; annual crops need to be rotated with perennial ley crops like sugarcane

Class V : vleis, pans and water courses; usually too wet to cultivate; would need special drainage if it were developed for sugarcane; true wetland and riparian land should not be developed

Class VI : good soils on steep land; moderate potential; difficult to mechanise and expensive to conserve; suitable for sugarcane but not for annual crops

Class VIF : deep rocky soils on steep land; suited to afforestation but not for mechanised sugarcane production

Class VII : too rocky, too steep or too shallow for sustained economic sugarcane production; suitable only for rough grazing or wildlife conservation.

Land classes (sometimes called the hazard of use classes) still only give the land capability and not its real potential to produce. Climate, especially temperature and the amount and distribution of rainfall, further affects this. However, soil has the ability to influence the effect of climate in the following ways, by modifying:

- the proportion of rain or irrigation water absorbed, and the proportion of runoff
- the amount of rain or irrigation water retained in the root zone
- the ease with which a soil releases available water to plants
- the rate at which roots are permitted to explore the soil for water and nutrients.

The above discussion shows the value of not only naming all the soils that occur on a sugarcane farm, but mapping them, perhaps plotting their relative boundaries, assessing their rooting depth, their total available water and determining the various land classes into which the different fields fall. By so doing, all cane growers should gain a new understanding of their farm's full potential, appreciate its limitations and aim to get the best economic yield from the land.

Independent of SASEX, the Department of Agriculture at Cedara has recently done excellent work in developing the concept and mapping of 590 Bioresource Units (BRUs) throughout KwaZulu-Natal, at a scale of 1:250 000 (Camp, 1995). Each of these BRUs is described in terms of rainfall, altitude, soils, topography and natural vegetation. More than 160 BRUs occur within the main cane belt.

Furthermore, Smith (1997) developed crop models for most agronomic crops, timber plantations and grazing capacities, which used the climatic and soils data from the BRUs to predict normal production under different levels of management. This information is invaluable in assessing the viability of many agricultural, forestry or pastoral alternatives for specific localities.

Camp, KGT (1995). The Bioresource Units of KwaZulu-Natal. Kwa-Zulu-Natal Department of Agriculture. Cedara Report N/A/95/32.

Smith, JMB (1997). Crop, pasture and timber yield estimates for KwaZulu-Natal. KwaZulu-Natal Department of Agriculture. Cedara Report N/A/97/9.

GLOSSARY

A

Acid rock Igneous rock with more than 75% SiO_2.

Acid soil Soil with a pH lower than 7,0.

Adsorption Retention of molecules or ions at the surface of a solid, a liquid or a gas.

Aerobic An organism or life process that can only exist in the presence of oxygen.

Aeolian Formed or deposited by wind.

Aggregate A single cluster of soil particles such as a ped, crumb, block or granule.

A horizon A topsoil consisting largely of mineral particles.

Alkaline soil Soil with a pH higher than 7,0.

Alluvium Unconsolidated materials deposited by running water in close proximity to streams and rivers.

Aluminium toxicity Aluminium in many soils occurs in quantities sufficient to harm plant growth, below pH 5,3 (water).

Amendment (ameliorant) Any substance used to alter the properties of soil to make it more suitable for plant growth, e.g. lime, gypsum, fertilisers.

Ammonification The biochemical process whereby ammonical nitrogen is released from nitrogen containing, organic compounds in the soil.

Anaerobic An organism or a process that does not utilise, or cannot exist in the presence of gaseous oxygen.

Anions Negatively charged ions.

Apedal See soil structure.

Association, soil A number of soils geographically occurring together.

Available nutrient That quantity of a nutrient element or compound in the soil that can be readily used by growing plants.

Available water capacity (AWC) The water content of a soil between field capacity and permanent wilting point, and expressed as millimetres per metre depth of soil.

B

Base saturation per cent The sum of the exchangeable Ca, Mg, Na, and K expressed as a percentage of the cation exchange capacity.

Basic rock A general geological term for igneous rock with more than 45% and less than 66% SiO_2.

B horizon Subsoil lying between the A and the C horizons.

Bleached horizon A light coloured and highly leached horizon.

Blocky See soil structure.

Buffer capacity The capacity of a soil to resist an induced change in pH.

Bulk density The mass of dry soil per unit volume.

C

Calcareous soil Soil containing sufficient free calcium carbonate to effervesce visibly when treated with dilute acid.

Carbon-nitrogen ratio The ratio of carbon to nitrogen in a soil or an organic manure.

Catena See toposequence.

Cation exchange capacity (CEC) The total exchangeable cations that soil colloids or clay can adsorb.

Cations Positively charged ions.

Cemented Having a hard, brittle consistency because the soil particles are held together by substances such as humus, calcium carbonate, or oxides of silicon, iron and aluminium. The hardness and brittleness persist even when wet.

C horizon A mineral horizon of weathered rock or other material.

Clay A soil separate consisting of particles of less than 0,002 mm in diameter (see soil texture)

Clay minerals Very small, naturally occurring crystalline compounds of iron, aluminium and silica, e.g. kaolinite, montmorillonite, illite.

Clayskins (cutans) Clay and humus which is washed into the soil and forms skins or coatings on the surface of peds or individual particles such as sand and stones.

Clod A compact, coherent mass of soil, of variable size, usually produced by ploughing or digging dry soil.

Coarse sand A soil separate consisting of particles 0,5 to 2,0 mm in diameter (see soil texture).

Columnar See soil structure.

Colloid, soil Very fine mineral or organic substances.

Colluvium A deposit of soil and or rock fragments accumulated at the base of steep slopes and transported by gravity.

Compaction Increased soil bulk density and decreased porosity due to the application of mechanical forces to the soil.

Concretion A local concentration of a chemical compound, such as calcium carbonate or iron oxide, in the form of a grain or nodule of varying size, shape, hardness and colour.

Consistency The resistance of a soil to deformation or rupture with varying amounts of moisture.

Crumb See soil structure.

Crust A compacted, brittle, surface layer of the soil, a few millimetres thick.

Cultivation A tillage operation used for preparing land for planting or later for weed control and loosening the soil.

D

Denitrification The biochemical reduction of nitrate or nitrite nitrogen to gaseous nitrogen in waterlogged soils.

Dystrophic soil A soil that has a low base status and has usually undergone marked leaching.

E

Effective rooting depth (ERD) The depth of a soil (excluding gravel, stones and rocks) in which about 85 to 90% of the crop roots are found. This depth varies with different crops.

Eluviation The removal of soil in suspension (or in solution) from any part of, or from the whole soil profile.

Erosion The wearing away of soil or rock fragments by running water, wind or ice.

Eutrophic soil A soil that has a high base status and has usually undergone little or no leaching.

F

Family, soil In the South African soil classification, it is a group of soils within a single form but comprised of a number of related soil series.

Ferricrete See hardpan.

Fertility, soil The status of a soil with respect to its ability to supply nutrients essential for plant growth.

Fertiliser requirement The quantities of certain plant nutrients needed (in addition to those supplied by the soil) to increase plant growth to an optimum level.

Field capacity (FC) The water a soil can hold against gravity.

Fine sand (and very fine sand) Soil separates consisting of particles 0,05 to 0,25 mm (see soil texture).

Fixation The process of converting a plant nutrient in the soil, from a readily available form to a less available form.

Form, soil A class of named soils, each defined by a unique vertical sequence of diagnostic horizons or materials

Friable Soils that easily crumble.

G

Gley A soil material developed under prolonged waterlogging.

Gravel Rock fragments more than 2 mm in size and less than about 7 mm in cross-section.

H

Hardpan A hardened subsurface layer which may be caused by the strong cementation of soil particles and organic matter, by materials such as sesquioxides (mainly iron), calcium carbonate and silica. Also known as ouklip, ngubane, laterite, ironpan, ferricrete, calcrete, silcrete, etc.

Hectare furrow slice The volume of a hectare to a depth of 20 cm.

Horizon, soil A soil layer, bounded by air, hard rock or soil material that has different characteristics.

Hydraulic conductivity A measure of the rate of flow of water through a soil profile.

Hydromorphic soils Soils with features such as gleying, mottling, or concretionary horizons, resulting from permanent or intermittent water tables, e.g. Katspruit, Kroonstad, Longlands and Rensburg forms.

I

Illuviation Deposition of soil material, removed by percolating water, from one horizon to another; usually from an upper to a lower horizon in the soil profile.

Indurated Hardened consistency caused by cementing.

Intake rate (steady) The rate at which water enters into a moist soil from above.

Intergrade A soil which cannot be accommodated in a single class and which has some features of two or more classes.

Iziduli A Zulu word for termite mounds.

K

Kaolinite A non-swelling clay mineral with a 1:1 crystal structure.

L

Lamellae Thin horizontal bands of clay caused by illuviation and found in young soils.

Leaching The removal of materials in solution from a part or from the whole of the soil profile.

Lime Agricultural or calcitic lime is calcium carbonate ($CaCO_3$) and dolomitic lime is a mixture of calcium and magnesium carbonate ($CaCO_3.MgCO_3$).

Lime requirement The amount of agricultural lime, or the equivalent of other specified liming materials, required to raise the pH of the soil to a specified value, under field conditions.

Loam A soil textural class (see soil texture).

Luvic subsoils Have markedly more clay than the horizons above; this is not the case with non-luvic subsoils.

M

Medium sand A soil separate consisting of particles 0,25 to 0,5 mm in diameter (see soil texture).

Mesotrophic soil A soil that has a moderate base status and has not undergone too much leaching.

Milli-equivalents per cent (me%) Concentration of cations expressed as milligram equivalents per 100 grams of clay.

Mineralisation The conversion of organic forms of elements in the soil (particularly N, P, S) to inorganic forms as a result of microbial decomposition.

Minimum tillage The minimum amount of soil disturbance necessary for crop production.

Montmorillonite A swelling or cracking clay mineral with a 2:1 crystal structure.

Mottles Spots or blotches of contrasting colours occurring in wet soils.

Mulch Any material such as trash, plastic film, loose soil or stones on the surface of a soil, which reduces evaporation and protects it from erosion.

N

Ngubane A Zulu word meaning gravel (see hardpan).

Nematicides Chemicals which are used to control plant feeding nematodes (eel-worms).

Nitrification The biochemical oxidation of ammoniacal to nitrite and nitrate nitrogen under conditions of good soil aeration.

O

Organic matter, soil The organic fraction of the soil.

Ouklip An Afrikaans word describing hard plinthite or hardpan.

P

Parent material The underlying bedrock or unconsolidated material from which the soil is derived.

Peat Unconsolidated material consisting of partly decomposed organic matter accumulated under waterlogged conditions.

Ped A unit of soil structure such as an aggregate, crumb, block, prism or granule, formed by natural processes.

Permeability, soil The ease with which water (or air) passes through a soil.

pH, soil The degree of acidity or alkalinity in a soil, expressed as a pH value.

Platy See soil structure.

Pore space Total space not occupied by soil particles in a volume of soil.

Prismatic See soil structure.

Profile, soil A vertical section of soil, through all its horizons.

R

Ridge planting Planting on a raised bed or ridge. Where this is practiced, it is essential that all crop rows are free draining over their entire length.

Rhizosphere A zone of soil where the microbial population is altered (both in kind and in numbers) by the presence of plant roots.

S

Saline soil (witbrak) A soil with a high soluble salt content in which calcium and magnesium are dominant and sodium is not a major constituent; pH is less than 8,5.

Saline-sodic soil (witbrak) A soil with a high soluble salt content in which sodium is the dominant exchangeable cation and pH is less than 8,5.

Sand See soil texture.

Saturation extract The solution which is extracted under suction from a saturated soil paste.

Sediment Deposited material varying from hard rock to recent unconsolidated material.

Self mulching A process of swelling and shrinking of soil which gives rise to a loose surface layer of well aggregated granules or blocks.

Sesquioxides Highly oxidised compounds of iron, aluminium and to a lesser extent manganese occurring in the soil.

Silt A soil separate consisting of particles 0,002 to 0,05 mm in diameter (see soil texture).

Slickensides Polished or grooved surfaces within the soil resulting from part of the soil sliding against adjacent material. They occur in Vertic soils.

Sodic soil (swartbrak) A soil with low salt content but, unlike other soils, the ratio of sodium to other cations (i.e. SAR) is harmfully high; pH is more than 8,5 and soil structure is very poor.

Sodium adsorption ratio (SAR) A measure of the quality of salts in solution (e.g. in a soil saturation extract or in irrigation water) and it depends on the sodium content relative to the calcium plus magnesium content.

Soil colour The colour of the soil reflects its various characteristics, e.g. dark topsoils either signify organic matter or black clay minerals; red soils are well drained and mature; mottled soils indicate waterlogged conditions.

Soil conservation Practices designed to reduce soil erosion and increase the amount of water available to a crop.

Soil management The sum total of all the tillage operations, conservation practices, crop husbandry, fertiliser, lime and other treatments conducted or applied to a soil for the production of plants.

Soil structure The natural aggregation of primary soil particles into secondary units or peds such as the following :

- **apedal** Having a weak structure or a porous non-visible structure.
- **blocky** Moderate to strong, smallish, angular block-like peds.
- **columnar** Large columns with rounded tops, usually with prominent clayskins.
- **crumb** A soft, porous more or less rounded ped, from 1-5 mm in diameter.
- **platy** Thin compacted plates found on top of bare soil which tends to crust.
- **prismatic** Large compacted prisms with flat tops, usually with prominent clayskins.
- **structureless** Single grained or without structure.

Soil texture The relative proportions of sand silt and clay in the soil and a description of the dominant grade of sand. See diagrams of the two soil textural triangles in Appendix 3 (page 155).

Swelling or cracking clay A group of 2:1 clay minerals such as montmorillonite, which swell when wet and shrink or crack when dry.

Subsoiling Breaking of compacted subsoils, without inverting them, by dragging a heavy tine or chisel through the soil, deeper than the normal plough depth.

System, soil A broad geographical association of soils which share a similar climate, altitude and age of land surface.

T

Threshold values The minimum level of each nutrient that soils or plants should contain to ensure that a deficiency does not exist.

Tillage Working soils mechanically or by digging, with the object of improving conditions for plant growth.

Tongues, soil Conical penetrations of material from an overlying horizon into the horizon beneath it (usually into weathering rock).

Toposequence A sequence of related soils that differ from one to another, primarily due to their position on the landscape, and to seepage water from higher up the slope.

Total available water (TAW) The available water capacity (AWC) multiplied by the effective rooting depth (ERD) of a particular soil (mm).

W

Water table Free standing water in or below the soil profile. Perched water tables often occur in the soil and these are separated from the ground water by drier layers.

Weathering All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents.

Wilting point The point in a range of soil water content, below which the majority of plants remain permanently wilted (PWP).

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KEY TO SOIL FORMS

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