AGRIMOTION

SCIENTIFIC | INDEPENDENT | PRECISE

Soil Report

Rietvallei

Robertson, Western Cape

January 2024

info@agrimotion.net
+27 21 851 1051
+27 86 637 9807

Stellenbosch University, AgroHub,
Welgevallen Experiment Farm,
Stellenbosch, 7600

Postnet Suite #704
Privaatsak X15
Somerset-Wes, 7129

www.agrimotion.net
@Agrimotion2013

TABLE OF CONTENTS

SUMMARY

- A soil survey was conducted across a 16 ha area at Rietvallei to evaluate the soil's suitability for perennial crop production.
- In general, the soils before amelioration has a medium-low to low suitability for perennial fruit production, however if the correct amendments and soil preparations are made the soil suitability goes into the medium to medium-high category.
- The area surveyed consist mainly of weathering rock that if ripped and ridged can be very good soils for production. Without these actions the soil depth will be limiting to deeper root development.
- Chemically, the soil is manageable - the possible challenges are low pH (KCl) that will require Calcitic lime and low Phosphate levels that will require rectification.
- Soil salinity is no risk as the soil resistance is above 500ohm for every sample analysed.

INTRODUCTION

A soil survey was conducted by Danie Kritzinger at Rietvallei (*Robertson, Western Cape*) during January 2024 to evaluate the soil's suitability for perennial crop production.

METHODOLOGY

2.1 SOIL CLASSIFICATION & DESCRIPTION

Table 1. Survey details.

Soil classification system:	*Soil Classification: A Taxonomic System for South Africa (1991)*
Total surveyed area:	16 Ha
No. of observations:	8
Observation grid:	Reconnaissance
Sampling procedure:	Grid sampling

A total of 8 soil observations was made across the surveyed area by means of the profile method **(Soil Observation Positions map)**. Observations entailed investigating & classifying the soils according to the South African soil classification system (*Soil Classification: A taxonomic system for South Africa*).

- Soil classification entails identifying and distinguishing different **diagnostic soil horizons.**
  - *Horizons are horizontal layers which develop as a result of natural soil forming processes either from underlying rock or transported material.*
  - *Diagnostic horizons represent soil horizon types with specified characteristic as set out in the South African soil classification system.*
- A specific sequence of (diagnostic) horizons determine the **soil form**.
- Variations inherent to a specific sequence of (diagnostic) horizons i.e. soil form, are recorded by means of a **soil family**.
- Each sequence of diagnostic horizons is the result of a combination of soil forming factors.
  - *The same horizon type can develop under different conditions and subsequently differ with regards to clay content, sand grade, wetness, coarse fragments, depth, structural development, colour, etc.*
- With such variation known to occur within each soil form, together with the potential impact such differences may have on crop production, it is necessary to collect additional information beyond that which is required for pure scientific classification. Additional parameters more relevant to crop production are captured as part of a detailed profile description process.

2.2 SOIL SUITABILITY ASSESSMENT

A soil suitability index (SSI) value is assigned to each soil observation position. The index ranges between 1 (very poor) to 10 (exceptional) and it serves as an indication of the soil's **natural capacity to support perennial crop production in its current, unaltered state**. The most important factors that are considered when determining the suitability of a soil for perennial crop production include:

1) **The nature and diversity of limiting features throughout the soil profile,**
2) **the intensity or degree in which this limiting feature(s) is expressed, and**
3) **the depth at which the limitation occurs.**

It is important to note that:

a. various cultivation practices can be applied to improve the soil's suitability (e.g. deep tillage, ridging, drainage etc.), and
b. different soil types are more, or less suitable to different crops or cultivar, depending on the plant or variety's natural tolerance towards different soil conditions.

Interpretation:

The soil suitability index is a numerical value that serves to consolidate the soil characteristics observed by the soil scientist with his/her interpretation of its constraint to crop cultivation. If a soil has a low SSI, cultivation practices can be used to improve the soil, or alternatively a crop can be selected which will be better suited to the natural or altered soil conditions.

The management practices needed to improve the soil's suitability are variable and specific to each limitation type.

To quantify the potential improvement to the soil following specified cultivation practices, an additional suitability rating is also awarded to each observation known as the **ameliorated soil suitability index (ASSI).** The ASSI is a measure of the soil's potential to **sustain perennial crop production in an altered state**, following applicable physical and chemical management actions (**Ameliorated Soil Suitability Index map**).

Both SSI and ASSI are colour-coded according to the following colour scheme:

SSI Rating	Suitability Description	SSI Rating	Suitability Description
8	Very High	4	Medium Low
7	High	3	Low
6	Medium High	2	Very Low
5	Medium	1	Not suitable for planting

2.3 SOIL SUITABILITY & EFFECTIVE PROFILE DEPTH

Soil suitability distribution is presented as the background colouring on the **Soil Map**.

Effective profile depth refers to the current soil depth (i.e. volume) available for root development and is presented on the **Effective Profile Depth map.** As a rule, perennial tree crops require at least 60cm of soil for adequate root development.

SOIL CLASSIFICATION

3.1 GENERAL DESCRIPTION

The classified form & family at each observation position are indicated on the **Soil Map**.
A general description of each of the identified soil forms as well as their most relevant limiting features to crop production are provided in **Table 2**.

Table 2. Soil forms and major limiting features observed at Rietvallei.

Soil Form	Frequency %	General Description	Limiting Factors
Gs - Glenrosa	75	Shallow, weathered rock.	High coarse fraction, Weathered rock.
Pr - Prieska	13	Structureless, calcareous subsoils with variable colour expression overlying hardened carbonate layers.	Free carbonates and Alkalinity, Hardpan carbonate.
Sw - Swartland	13	Blocky structured soils overlying partially weathered rock.	Dense clay, Strong structure, High coarse fraction, Weathered rock.

The variation, degree and depth at which limiting soil features are expressed determine how it will influence crop production. A general explanation of the major limiting soil features deemed relevant to perennial crop production are presented in Appendix 3A.

Detailed soil description codes are provided in Appendix 3B.

SOIL CHARACTERISATION

4.1 PHYSICAL CHARACTERISATION & MANAGEMENT ZONE DELINEATION

A soil management zone (SMZ) represents a body of soils with similar physical and morphological characteristics. The similarity in characteristics imply that similar management intervention would be required to optimise the productivity of the soil resource. Soil type, together with features such as clay content, coarse fraction content and sand grade (all related to the irrigation requirements for perennial orchards) serve as the distinguishing criteria used to group soils into larger soil management zones.

- Soil management zones are delineated and numbered on the provided **Soil Map.**
- General soil characteristics within each of the delineated management zones are provided in **Table 3**.
- Additional maps for clay % and coarse fraction % per classified soil horizon are also provided for further reference.

Table 3. Physical soil characterisation per soil management zone at Rietvallei.

1 (Click For Photo)	**Gs - Glenrosa**	*Effective depth (cm):*	**80**
		Topsoil	**Subsoil 1**
	Depth (cm) :	30	0
	Colour:	Light Brown	0
	Clay %:	6	6
	Sand Grade:	Me	Me
	Coarse Fragments (Vol %):	40	70
2	**Sw - Swartland**	*Effective depth (cm):*	**30**
		Topsoil	**Subsoil 1**
	Depth (cm) :	30	50
	Colour:	0	0
	Clay %:	8	30
	Sand Grade:	Me	Me
	Coarse Fragments (Vol %):	40	40
3	**Pr - Prieska**	*Effective depth (cm):*	**80**
		Topsoil	**Subsoil 1**
	Depth (cm) :	20	40
	Colour:	0	0
	Clay %:	5	8
	Sand Grade:	Fi	Fi
	Coarse Fragments (Vol %):	20	40

4.2 CHEMICAL CHARACTERISATION

Grid samples were collected in selected areas at Rietvallei to a depth of 40 cm.

Summarized sample analyses are presented in Appendix 4B.

Generally, the area surveyed has a low pH (KCl) which will negatively affect nutrient availability in the soil. The pH (KCl) can however be corrected by application of a suitable lime program.

There is an area (S1_1) that is slightly saline - it is not a major concern at present but should be monitored over time.

The area around S5 is sodic and will require gypsum. This area is also low in phosphorus - this can be corrected with the application of the nutrient during soil preparation.

In general, the soil is low in in K and Ca, however this can be corrected with an in-season fertiliser program.

A general explanation of the major limiting soil chemical conditions are provided in Appendix 4C.

Regards,

Danie Kritzinger

Director | Soil Scientist | Horticulturist

Pr. Sci. Nat (100045/14)

MSc Agric Soil Science

+27 73 703 4588

danie@agrimotion.net

APPENDIX 3A – GENERAL DESCRIPTION OF LIMITING SOIL FEATURES

1. **FREE CARBONATES & ALKALINITY**

(Click to return)

Alkalinity is a property most commonly associated with calcareous soils, although it can also be present in gypsiferous, saline, and sodic soil types. It is defined as soils with a $pH_{(H20)}$ > 7 and is the result of an accumulation of carbonates, most commonly calcium carbonate ($CaCO_3$) i.e. *free lime*, but can also include sodium carbonate (Na_2CO_3) and magnesium carbonate ($MgCO_3$).

Calcareous soils are defined as soils containing sufficient calcium carbonate (>15% calcium carbonate equivalent) to visibly effervesce when treated with cold 0.1M HCl. These soils usually exhibit a soil $pH_{(H20)}$ > 8, resulting in its inclusion as part of the alkaline soil grouping. The presence of free lime is usually regarded as a limitation but can beneficially improve the physical stability of soils and result in a more porous and friable medium for root development.

Limitations imposed by high soil pH and specifically excessive concentrations of $CaCO_3$ include:
- Low phosphorous availability
- Low micro nutrient availability (specifically Cu, Mn, Zn & Fe)
- Excessive Ca levels (in relation to Mg and K)
- Lower efficiency of nitrogen fertilizer (due to greater volatilization)

Hardpan carbonate layers represent soil horizons in which calcium carbonate has accumulated to the extent that the majority of the soil pores have been filled with precipitated carbonate resulting in the formation of a massive, continuously cemented layer that cannot be penetrated by roots and is slowly permeable to water. By definition these horizons are not only limiting to root growth due to their chemical state but due to their physical properties as well.

2. **WEATHERING ROCK & HIGH COARSE FRACTION**

(Click to return)

Rock in different stages of weathering are common in many soil profiles, especially along higher lying topographies. Rock is always denser and more impervious to air, water, and roots than the soil horizons associated with it in the landscape. The degree of weathering, the original structure of the material (vertically or horizontally orientated) and the depth at which it occurs greatly influences the intensity of the limitation as well its potential to be alleviated through man-made actions. Advanced weathering results in softer and more porous layers which will be even more penetrable to roots and prone to mechanical improvement if vertically orientated and natural planes of weakness are exposed. On the contrary, the shallower the rock and the less weathered and harder it is (i.e. ***hard rock*** *layers*), the greater the negative influence will be on root penetration and water infiltration and the more inputs will be required to create a sufficient soil medium. In addition, weathered rock layers may exhibit signs of wetness (hydromorphic features) and contain varying quantities of coarse fragments.

Coarse fragments refer to fine gravel (2-25mm), gravel (25-75mm), stones (75-250mm) and boulders (>250mm) that form part of the soil volume. The higher the coarse fragment content, the lower the volume of fine and reactive soil material. In essence, coarse fragments cause an increase in total as well as macro-porosity. The greater distribution of macro pores through the soil volume implies lower reactive surface area for retaining moisture and nutrients (i.e. lowered water and nutrient holding capacities) but an increased hydraulic conductivity (the ease with which water moves through a soil medium).

Where the textural composition of soils is dominated by a high medium to fine sand- and/or silt content, coarse fragments can serve to decrease the compactability of such soils. Often gravel also serves to limit the formation of coarse (and more limiting) subsoil structure.

The limitations to crop production imposed by a high coarse fraction is similar to those for soils with a low clay content i.e. the soils tend to dry out quicker, are easily leached and have limited capacity to store nutrients.

3. STRONG STRUCTURE, SWELL-AND-SHRINK PROPERTIES AND DENSE CLAY

(Click to return)

Soil structure refers to the natural aggregation of soil particles into distinctive structural units. Structural expression varies in grades from weak or structureless (apedal) to moderate and strong. The development and expression of structural units is the result of alternating wet and dry conditions that cause continuous cycles of expansion and contraction. In the dry state, the soil tends to shrink, forming distinctive planes of weakness expressed as cracks. These cracks vary in size and essentially delineate individual structural units. The shape of these structural units is characteristically blocky or prismatic.

Structural development is primarily a function of both the clay content and the type of clay mineral that is present within the soil. With smectitic (2:1) clay minerals that have a strong tendency to swell-and shrink, structural development is naturally more pronounced. Similarly, in soils comprised of kaolinitic (1:1) clay that is less prone to swelling and shrinking, strong structural development is more dependent on a higher clay content and/or high levels of exchangeable sodium and/or magnesium.

Strong structure and **dense clay** represent a physical limitation to root growth and water infiltration. In the presence of dense and hard structural units it becomes increasingly difficult for roots to penetrate and water to infiltrate resulting in poorly developed root systems and/or anoxic soil environments. Under extreme **swelling and shrinking** conditions such as characteristic for vertic soils, roots can be severely damaged and even pruned as soil moves to expand and contract. Clay density becomes even more of a limitation where present in profiles with variable textured layers. The transition from a light textured, sandy layer with an abundance of macro pores, to a dense clay layer with relatively few macro pores and *vice versa*, will influence permeability and restrict gas exchange and root development.

4. HARDPAN LAYERS

(Click to return)

The accumulation of various chemical and/or organic soil components often results in the irreversible cementation of soil particles. Chemical or organic compounds can precipitate out in between soil pores and result in the formation of hardened and continuous layers over time. Such hardpan layers represent a physical limitation to root growth and water infiltration and thereby decreases the effective useable depth of the soil profile. The following hardpan layers are common:

a) **Dorbank.** Reddish-brown hardpan layers with a platy or massive structure that form due to the accumulation of silica. Such layers are confined to drier climatic regions which consequently mean that salinity and/or sodicity can also be prevalent.

b) **Hardpan Carbonate.** White to pale grey layers comprised of cemented calcium carbonate. Such hardpan carbonate layers represent both a physical and chemical limitation to crop production.

c) **Hard Plinthite** (laterite, ferricrete, *ouklip, koffieklip*)**.** Yellow-brown to rust-brown layers comprised of iron (yellow to red) and manganese oxide (dark-brown to black) concretions that over time have become cemented together to form a continuous hardpan layer. These layers develop due to periodic water saturation and therefore in landscapes with a sustained fluctuating/perched water table.

d) Placic pan. These thin, rust to dark coloured layers develop in podzolic horizons due to an irreversible cementation of iron, manganese and organic material complexes. Placic pan development is usually associated with wetter soil conditions.

5. HARDSETTING, DENSIFICATION, CRUST FORMATION & BLEACHING (PHYSICAL INSTABILITY)

(Click to return)

The **physical stability** of a soil refers to the resistance of fine soil particles to dispersion following the addition of water. In unstable soils, clay and fine silt particles move with water on the soil surface or through the profile. These finer particles are deposited in vacant soil pores following the drying of the soil which results in greater profile density and lowered porosity. As a result, soil degradation processes such as erosion, compaction and crusting are prevalent.

Soil stability is a function of the interaction of several features, most importantly:

- EC (Higher EC counteracts dispersion)
- pH (Higher pH amplifies dispersion)
- Fe oxide content (Greater FE oxide content will stabilise fine soil particles)
- Organic matter content (Greater organic matter content will stabilise fine soil particles)
- Exchangeable Na and Mg (Sodium and to a lesser extent, Magnesium, amplifies dispersion of finer soil particles whilst Calcium tends to stabilise and limit mobility)
- Texture (Soils with a high silt content and/or finer sand fraction tend to be more unstable)
- Clay mineralogy (Illite is the clay mineral most susceptible to dispersion)

Hardsetting tendencies, surface crust formation and bleaching are all consequences of or related to physical instability and the limitations presented by this characteristic.

Hardsetting soils are characterised by a **densification** (increased density) in surface and/or subsurface horizons. Because of their instability to wetting, cultivated hardsetting soils become almost homogenous masses upon drying and present physical problems such as high soil strength (which restricts the suitable period for soil tillage and present a strong physical impediment to root development), poor infiltration, and crusting, which tend to adversely affect crop performance and management.

Soil crusts are relatively thin, dense, somewhat continuous layers of non-aggregated soil particles that form on the surface of tilled and exposed soils. Water droplets striking the aggregates of unstable soils together with water flowing over such soil surfaces cause fine soil particles to disperse. These particles wash down, settle into and block surface pores causing the soil surface to seal over and preventing water from soaking into the soil. Surface crusts greatly reduce infiltration and increase runoff and erosion. It can also limit seedling emergence due to the relatively hard surface that is difficult for young roots to penetrate.

Bleaching is a soil discolouration phenomenon whereby horizons exhibit a pale greyish colouration due to the loss of pigmentation agents, specifically Fe oxides and organic material, from most commonly, the upper part of the soil profile. Due to the contribution of these components to not only soil colour but also clay and aggregate stabilisation, their consequent removal is correlated to the physical instability of soils. As a result, hardened surface crusts tend to develop in bleached topsoils whilst in bleached subsoil layers the greater density causes material to become noticeably harder under dry soil conditions.

APPENDIX 3B - SOIL CODES

(Click to return)

Profile No.	Soil Code ABOVE	Soil Code BELOW
S1	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S2	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S3	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S2_1	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S3_1	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S4	*33 Gs 2211 so(6)+f2g3k2 (9/6) (4.5)*	*g2k2 (6) (Me) 2*
S1_1	*242 Pr 2110 hk(8)+f2g3k3 nc(8)+f2g2 (/) (4.5)*	*g2 (5) (Fi) 2*
S5	*353 Sw 2221 so(16)+f2g3k2 vp(30)+f2g2 (/) (3.5)*	*g2k2 (8) (Me) 2/3*

APPENDIX 4A – VISUAL REPRESENTATIONS

<table>
<tr><th colspan="2">Example of soil horizon sequence in Soil Management Zone 1. (CLICK TO GO BACK)</th></tr>
<tr><td>Horizon Sequence</td><td>Soil Form: Gs - Glenrosa</td></tr>
<tr><td>A Horizon: Orthic A</td><td rowspan="2"></td></tr>
<tr><td>Subsoil 1: Lithocutanic B</td></tr>
<tr><th colspan="2">Example of soil horizon sequence in Soil Management Zone 2.</th></tr>
<tr><td>Horizon Sequence</td><td>Soil Form: Sw - Swartland</td></tr>
<tr><td>A Horizon: Orthic A</td><td rowspan="3"></td></tr>
<tr><td>Subsoil 1: Pedocutanic B1</td></tr>
<tr><td>Subsoil 2: Lithocutanic B2</td></tr>
<tr><th colspan="2">Example of soil horizon sequence in Soil Management Zone 3.</th></tr>
<tr><td>Horizon Sequence</td><td>Soil Form: Pr - Prieska</td></tr>
<tr><td>A Horizon: Orthic A</td><td rowspan="3"></td></tr>
<tr><td>Subsoil 1: Neocarbonate B1</td></tr>
<tr><td>Subsoil 2: Hardpan Carbonate B2</td></tr>
</table>

**Not part of horizon sequence according to Soil Classification: A Taxonomic System For South Africa (1991).*

**Defined as unspecified material in horizon sequence according to Soil Classification: A Taxonomic System For South Africa (1991).*

APPENDIX 4B – SUMMARIZED SOIL CHEMICAL ANALYSIS

Go Back

Concern	Very Low	Low	Moderate	Ideal	High	Very High

SampleID	Depth	pH (KCl)	Resistance Ohm	Phosphate Bray II ppm	Potassium K ppm	Total Carbon %	ESP Sodium Na %	Potassium K %	Calcium Ca %
S1	40	3.7	2630	8	70.9	0.88	3.61	3.13	13.42
S1_1	40	7.9	610	4	128	1.13	2.92	1.15	82.22
S2_1	40	4	1720	8.8	57.7	0.95	3.94	2.65	21.49
S3	40	3.8	810	10.1	88.1	0.88	4.91	3.83	23.71
S4	40	3.8	2360	3.9	102	0.8	4.69	5.33	32.59
S5	40	5.7	1240	3.2	141	0.83	10.91	7.05	42.88

SampleID	Depth	Magnesium Mg %	Effective Cation Exchange Capacity ECEC	Acid Saturation %	Sulfur ppm
S1	40	51.6	5.81	28.28	4.7
S1_1	40	13.7	28.46	0	12.7
S2_1	40	34.03	5.58	37.84	8.8
S3	40	44.02	5.91	23.63	22.5
S4	40	30.55	4.91	26.87	4
S5	40	31.18	5.13	8.01	3.4

APPENDIX 4C – GENERAL DESCRIPTION OF LIMITING SOIL CHEMICAL CONDITIONS

1. SODICITY

(Click to return)

Sodicity refers to a condition where a soil contains excessive amounts of sodium (Na^+). Although sodium in soils are primarily supplied by Na^+ salts like NaCl, salinity is not a prerequisite for sodicity. Soils in which these two conditions occur simultaneously are known as ***saline-sodic soils***.

Sodicity is quantified by either one of two parameters:

1. The exchangeable sodium percentage (ESP) indicates the degree to which soil exchange sites are occupied by sodium (Na^+) ions. A soil with an ESP exceeding 15% is deemed to be sodic ('natriumbrak') although practical experience has indicated that in Southern African soils the negative effects attributed to high sodium levels are already experienced at ESP values of 6-8%.
2. The sodium adsorption ration (SAR) is the ratio of Na^+ to Ca^{2+} & Mg^{2+} in soil solution and is calculated as follows:
   $SAR = Na^+ / [(Ca^{2+} + Mg^{2+})/2]^{0.5}$
   Soils with SAR values exceeding 13 are considered to be sodic.

Sodic soils are physically unstable and highly dispersive in fresh water. Excessive sodium (exacerbated by high levels of Magnesium) causes soils to set hard upon drying, become dense and impermeable with depth and form surface crusts (See *Hardsetting, densification, crust formation & bleaching* for additional information). This can slow water infiltration and internal drainage but also exacerbate erosion and compaction.

The effects of excessive sodium are less severe in sandy soils. Where salts of potassium, magnesium and especially calcium are present they are also known to counteract the negative effects of sodium by acting as bridging-cations between colloidal particles such as clays and organic matter. In this manner they flocculate clay particles and limit dispersion. It is therefore possible that the negative effects caused by sodium is masked by excessive salts in a saline-sodic soil environment. It must be noted that such soils must be leached with slightly saline irrigation water (preferably containing Ca^{2+} ions) to maintain structural integrity whilst leaching sodium from the plant root zone.

2. SALINITY

(Click to return)

Salinity refers to the concentration of all soluble salts in soil or water and is measured as electrical conductivity (EC) or resistance.

Soils are considered to be saline ('brak') when:

1. EC values exceed 4 mS/cm (although negative effects for sensitive crops start to occur at 2 mS/cm), or
2. resistance is below 300 Ohm (although negative effects for sensitive crops start to occur at 500 Ohm).

Salinization is the process that increases the salt content or *salinity* in soils. A soil may become *saline* through weathering of parent rock, irrigation with saline water, influxes of saline groundwater or an overapplication of fertilisers. When salts are supplied to soils through one of these sources, they may become concentrated in the rootzone through evaporation and rising water tables. Excessive salinization at the soil surface is often recognizable as a thin, white layer of precipitated salts.

The effects of salinity on crops are analogous to those caused by drought stress.

- Plants absorb water and nutrients into their roots through a process called *osmosis.*
- As salts accumulate in the soil solution, the osmotic pressure increases relative to that in the roots. Water will move out of the roots and into the soil solution to equilibrate the osmotic pressure potential.
- This mechanism causes plants to exhibit symptoms of "drought stress" even though there is enough moisture in the rooting zone.

Apart from moisture stress, plants grown in saline soils accumulate various cations and anions in their leaves that can easily reach toxic levels. This can result in stunted, yellow foliage and leaf margin scorch.

3. ACIDITY

(Click to return)

Acidity is the opposite of alkalinity and as is likewise measured on the pH scale. A soil is considered acidic when the pH drops to below 7 (neutral). For optimal nutrient availability, crops require a slightly acidic pH close to 5.5 (measured in KCl). When the pH drops below 5.5 soil acidity will hamper crop performance.

Soil acidification is a natural process which is accelerated by agricultural practices such as irrigation and the addition of nitrogen fertilisers.

- Rain & irrigation water facilitates the leaching of basic cations from the soil, leaving behind hydrogen ions that decrease the pH. Natural acidic conditions therefore occur in high rainfall areas.
- When soils are well aerated, periodic additions of water may also cause a slight decrease in pH as a result of carbon dioxide (CO_2) reacting with water to form carbonic acid (H_2CO_3).
- In nitrogen fertilizers containing ammonium ($\mathrm{NH_4^+}$), the conversion of ammonium into nitrate ($\mathrm{NO_3^-}$) is a process which generates hydrogen ions that are released into the soil solution.
- In addition, nitrates are easily leached and can facilitate the leaching of basic cations by binding to and transporting these nutrients out of the rooting zone.

As the pH of a soil drops it reflects a direct increase in the hydrogen content of the soil. Acidic cations such as aluminium and iron are indirect sources of acidity as they generate free hydrogen through hydrolyses. Below a pH of 5.0 aluminium ions are soluble enough to reach toxic levels that retard root development. Other processes such as the decomposition of organic matter is also slowed, and most significantly, the availability of almost all plant nutrients are decreased (at variable acidic pH ranges). The capacity of soils with large variable charge components to hold onto or retain nutrients will also be significantly reduced at low pH values.