Information Sheet

6.4: Managing soil acidity

Soil acidity refers to the excess amounts of hydrogen (H^+) and aluminium (Al^{3+}). Excess H can dissolve soil minerals that release Al. The Al reacts with water to produce further H ions, while Al in the soil solution is toxic to plant roots. Soil acidity usually occurs in areas receiving high rainfall (>750 mm per year) and is thus typically associated with the rainfed regions of the sugarcane industry. Soils in the more arid regions (northern irrigated areas of Pongola region and Mpumalanga province) and in a few other areas of arid climate tend to be more neutral or even alkaline, though pockets of acidity occur there too.

Causes of soil acidity

Soil acidity is a natural process, caused by leaching of base cations, uptake of base cations by plants, release of organic acids when organic matter breaks down, and from acids in rainwater.

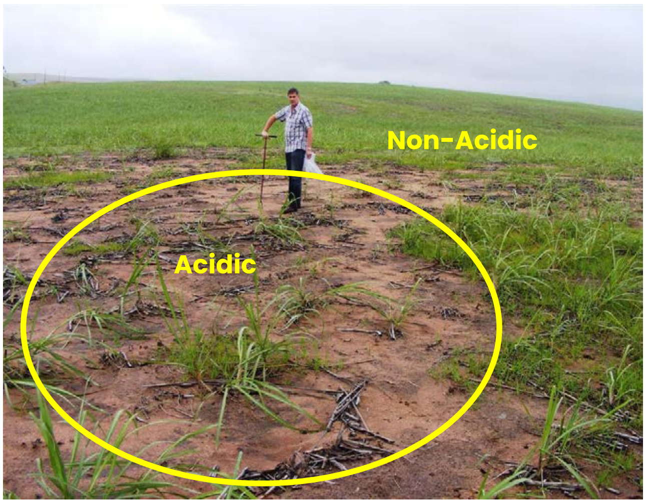
However, some agricultural practices greatly increase the rate of acidification. These include:

- Use of acidifying fertiliser, mainly ammonia-based nitrogen (e.g. urea, ammonium sulphate).
- Uptake of Ca and Mg by crops that are then exported from the soils during harvesting and crop removal.
- Increased rates of organic matter decomposition during intensive site preparation operations that release organic acids.
- Excessive nitrate leaching (this leads to Ca and Mg leaching, leaving behind H and Al).
- Poor liming management.

Measures and indicators of soil acidity

In the field, soil acidity often appears as patches of underperforming sugarcane that grow larger over time. Symptoms of Ca and Mg deficiency and sometimes Mn toxicity and acid-chlorosis (Fe deficiency) may be present in severe cases. However, the only true method to establish if the soil is acidic is soil testing. The SASRI Fertiliser Advisory Service (FAS) undertakes routine acidity measurements on soil samples submitted for top and sub soil analysis.

To understand the various measurements and their significance for your crop, see the SASRI booklet: *Understanding your FAS Report.* To ensure proper sampling for acidity (top and subsoil), see *Information Sheet 7.16: Soil sampling procedures.*



Patches of underperforming sugarcane potentially indicating soil acidity . ▲
Examine the crop for symptoms of Ca and Mg deficiency, as well as possible Mn toxicity and Fe chlorosis.

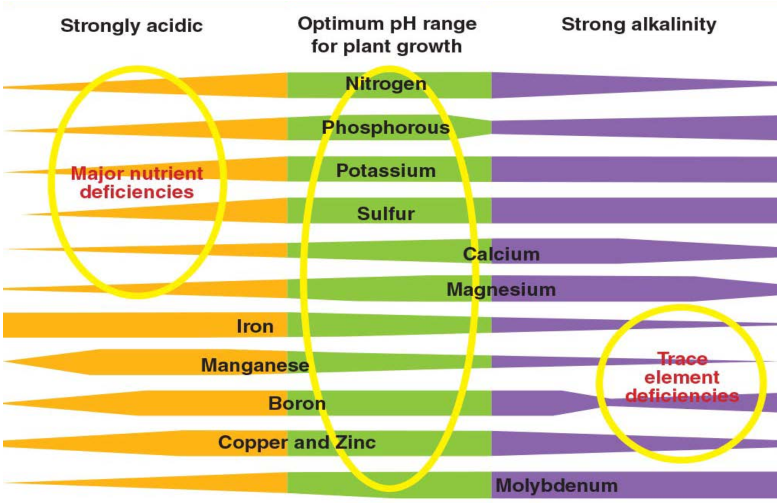
Impacts of soil acidity

Sugarcane is relatively tolerant of soil acidity and can grow in acidic soils. However, there is considerable evidence to indicate that reducing the level of acidity benefits nutrient availability, improves soil biological functioning and minimises negative impacts of excess Al on root health, with overall yield benefits for sugarcane production.

Excess Al is toxic to plant roots leading to stunted, stubby roots with damaged growing tips and reduced root hairs. This severely reduces uptake of water and nutrients.

▲ Excess acidity can lead to elevated Al levels in the soil that damage the root growing tips leaving short stubby roots with no fine root hairs. This greatly impairs the ability of the crop to take up water and nutrients.

Excess acidity is also usually associated with deficient levels of Ca and Mg in the soil due to these being leached out of the soil profile. Phosphorus (P) also becomes more strongly fixed with increasing levels of acidity. In some soil types, very high acidity can lead to Mn toxicity as this element becomes more available. This can induce an iron (Fe) deficiency known as acid-chlorosis. In general, plant nutrients are most available in the pH range from about 4.5 to 6.5.

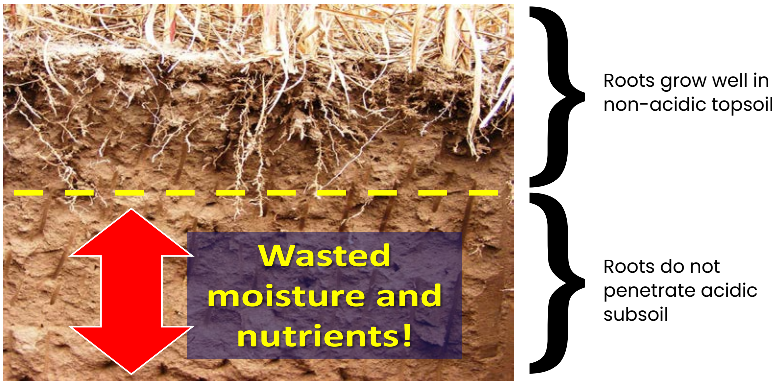


▲ The majority of plant essential nutrients are at their greatest availability in the pH($CaCl_2$) range between 4.5 to 6.5.

Soil organisms are also negatively affected by excessive acidity. High levels of acidity reduces their ability to decompose organic material and promote nutrient cycling, and availability. Liming of acid soils often improves the availability of nutrients through increased rates of decomposition of organic matter.

Subsoil acidity

Soil acidity is usually classified as being either topsoil acidity (0 -20 cm depth) or subsoil acidity (20 – 80 cm depth). Subsoil acidity is often overlooked as it occurs deeper in the soil profile. Soil acidity generally starts in the topsoil due to agricultural activities, and eventually migrates to the subsoil. In some soil types, the subsoils are naturally acidic due to natural weathering and leaching of base cations (e.g. many humic soil types). When subsoil acidity is very high, root growth into the deeper soil layers is impeded. This can negatively impact the crop's ability to extract water from deeper soil layers during times of deficient water supply, which can lead to earlier crop failure.



▲ Ameliorating subsoil acidity is important to improve root growth into deeper soil layers so that the plant can access moisture held at depth during drier periods as well as subsoil nutrient reserves.

Management of soil acidity

Given that the main culprit of agricultural acidity generation is the use of nitrogenous fertilisers and export of base cations, the following should be considered:

- Using the correct amount of nitrogenous fertiliser – over-application will promote greater acidity generation.
- Using nitrate-N sources where possible – they are less acidifying than ammonia-N sources.
- Adopting strategies to minimise leaching of nitrates (e.g. split N applications on very sandy soils).
- Retaining crop residues and adding other organic amendments – these can resupply cations such as Ca and Mg, while organic matter can buffer rates of acidity generation.
- Maintaining Ca and Mg levels at adequate amounts, especially in the topsoil (mainly through liming management).

Where acidity has already developed, then either lime (topsoil) or gypsum (subsoil) will be required, both of which introduce Ca into the soil. Calcium is essential for root growth while it also reduces negative effects of Al on root development.

Different strategies are used for plant and ratoon (or no-till) crops and for topsoil and subsoil acidity.

Management of soil acidity in plant crops (i.e. site preparation with incorporation)

Topsoil acidity

Liming materials (either Ca and/or Mg carbonates, oxides, hydroxides or silicates) can neutralise soil acidity when they dissolve in the presence of excess H. Liming materials are, generally, not very water-soluble and have very low mobility in the soil. For optimum benefit, these materials need to be thoroughly mixed with the soil surface layers.

Lime can also take several weeks to months to fully react in the soil, so sufficient time must be given when preparing a site for replanting. This is best done during a replant cycle soon after the last harvest and ideally any green manure crops are planted.

The advised rate of lime should be applied evenly across the soil surface and thoroughly cultivated into the top 20-30 cm of soil. Where very high rates (>10 t/ha) are required, it is often beneficial to split the application into two operations to promote more complete mixing.

Subsoil acidity

Gypsum (calcium sulphates and industrial by-products known as phospho-gypsum) are the most commonly used ameliorant to remedy subsoil acidity. Gypsum is a relatively soluble, neutral salt. This means it will dissolve with water, does not markedly alter the soil pH and thus can be readily leached through a soil profile.

In a plant crop situation, gypsum can be surface applied and ploughed into the surface soil (along with any advised lime). With sufficient rainfall, the gypsum will dissolve and leach to the deeper soil layers.

This can take several weeks with good rainfall. Because of this effective leaching action, gypsum is known to promote movement of Mg to the deeper soil layers. It is recommended that dolomitic lime be applied in conjunction with any gypsum to maintain soil Mg levels at adequate levels.

Management of soil acidity in ratoon and no-till crops

Liming for topsoil acidity

In ratoon and no-till crops, it is not possible to incorporate lime effectively into the topsoil. Due to the low mobility of the lime into the soil, topdressing is less effective (in the short term) to ameliorate acidity. Applying large amounts of lime in this manner is wasteful and the risk of erosion losses increases (especially on steeper slopes). For this reason, lime recommendations for top-dress application are substantially reduced (maximum rates advised range from 2 – 4 t/ha), and where possible, should be lightly harrowed into the soil surface. An improved strategy to promote movement of both Ca and alkalinity into the soil profile and alleviate Al toxicity, is to co-apply lime with gypsum.

It is important to note that, in cases where acidity levels are high (and not corrected at planting), it is likely that it will take several years of repeated top-dressing to completely ameliorate the acidic soil condition. This is due to the lower lime application rates and slower movement into the soil profile. Regular testing (at least every 2 years) is advised to monitor and adjust effects of surface treatments.

Gypsum for subsoil

Gypsum can be top-dressed and allowed to leach into the soil with rainfall. It is advised to co-apply gypsum with at least 1ton dolomitic lime to ensure Mg is not stripped from the topsoil layers during leaching.

For more information on liming and gypsiferous materials and ameliorants and how to use them, see *Information sheet 6.5*: *Liming materials and their use* and *6.6 Gypsum materials and their use*.

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