Information Sheet

6.5 Liming materials and their use

Liming materials are products that can neutralise soil acidity (See Information Sheet 6.4: Managing soil acidity). These products work by reducing the amount of hydrogen (H) ions in the soil thus lowering the pH. This reduces the amounts of toxic elements like aluminium (Al) and manganese (Mn), while improving the availability of several plant nutrients and stimulating root growth and soil biological activity. In this information sheet, the key benefits of liming are highlighted, some best practices for the use of lime are outlined and various aspects of lime quality are considered.

Advantages of liming of acid soils

- Increases soil pH.
- Lowers toxic levels of Al and Mn.
- Increases availability of phosphorus (and most other nutrients) for crop uptake.
- Adds calcium (Ca) (and sometimes magnesium (Mg)) to the soil.
- Improves nitrogen mineralisation and availability.
- Improves soil biological function.
- Enhances soil aggregation.
- Increases soil cation exchange capacity.

Risk of overliming ("limeshock")

- May cause an excessive increase in soil pH.
- Leads to reduced phosphorus (P) and micronutrient availability.

Note: *Applying liming materials to alkaline soils is ineffective as the material will not dissolve, nor does it effectively contribute to available calcium or magnesium levels.*

Effectiveness of liming materials

The effectiveness of limes to neutralise acidity are rated by their neutralising ability, called the calcium carbonate equivalence (CCE). This provides an indication of chemical purity of the product. This rating is scaled relative to the ability of pure calcium carbonate to neutralise acidity (which is set at 100%). This means a lime with a CCE of <100% is proportionally less effective than pure calcium carbonate at neutralising acidity, while CCE values > 100% means the material is more effective. The main types of liming material and their typical CCE ranges are given in the table below:

Type/name	Formula	Calcium carbonate equivalence (%)	Main elements
Pure calcium carbonate (Reference)*	$CaCO_3$	100	
Common liming materials			
Calcitic lime	$CaCO_3$	70-98	Ca
Dolomitic lime	$Ca/MgCO_3$	70-108	Ca, Mg
Burned or Quick lime	CaO	150 - 179	Ca
Hydrate or slaked lime	$Ca(OH_2)$	120 - 136	Ca
Ca-silicates/slags	$Ca/MgSiO_3$	50 – 90	Ca, Mg, Si

* Pure calcium carbonate is used as the reference value against which the neutralising value of liming materials are assessed and is set as 100%.

In addition to their CCE, the effectiveness of the liming material is affected by:

- **Particle size:** Smaller particles react faster and more completely than large particles. Particles <0.25mm are considered to be 100% effective (dissolve fully in acid soil), while particles between 0.8 to 2 mm are deemed mostly ineffective in the short-term, but provides some longer-term benefit for Ca supply (lime dissolves slowly over several years). Very coarse particles or lumps/pellets of lime (>2 mm) can remain unreactive in the soil for a very long time.
- **Chemical purity:** This refers to the chemical quality of the product, where higher amounts of non-liming (non-reactive) components (such as silica) will lower the effectiveness of the materials.
- **Hardness:** Limes derived from hard rock sources dissolve more slowly than those derived from soft sediments. The effect of this is less of a concern as the finer the lime material is.

When these factors are known and accounted for, the Effective Neutralising Value (ENV) or Relative Neutralising Value (RNV) can be determined. When purchasing liming materials, it is important to ensure the product meets minimum quality specifications. In South Africa, liming materials must conform to the regulations stipulated in the "Fertilizers, farm feeds, agricultural remedies and stock remedies act, 1947 (Act No. 36 of 1947)".
Main criteria include:

- CCE ≥ 70%.
- ≥ 50% of particles must be < 0.25mm and 100% must be < 1.7mm.
- Calcitic agricultural lime must contain a maximum of 4.3% Mg (or ≤ 15% $MgCO_3$).
- Dolomitic agricultural lime must contain a minimum of 4.3% Mg (or ≥15% $MgCO_3$).

(For additional legal requirements of limes visit https://www.gov.za/documents/fertilizers-farm-feeds-seeds-and-remedies-act-28-may-2015-1101). SASRI lime recommendations assume the lime to be used has an effective neutralising value of at least 75%.

Slaked and burnt limes

Oxide and hydroxide based liming materials tend to have much higher CCE than carbonate limes. This means that lower rates are required to achieve the same neutralising capacity as carbonate limes. These types of limes are also more reactive (will change the soil pH much quicker) than carbonate limes and will dissolve in water (carbonate limes are insoluble in neutral and alkaline water). The drawback of these types of liming materials are that they are highly alkaline (caustic). This means that in the presence of moisture they produce solutions with pH values >9. This can lead to caustic corrosion on equipment and handling must be done with adequate protection to prevent human contact and inhalation. The product must be handled under dry conditions and stored in dry locations. All equipment must be cleaned thoroughly after use to prevent corrosive damage.

In the soil, the rapid reaction with water leads to sharp increases in pH, and if not properly incorporated and distributed, can lead to severe nutrient immobilisation and increase ammonia volatilisation. In extreme cases, organic matter will dissolve, leading to biological crusts forming. When being applied as a soil treatment, all applications must be thoroughly incorporated immediately after application.

It is also not advisable that these products be top-dressed onto ratoon sugarcane as the caustic nature can lead to damage of the emerging tillers.

Carbonate limes

Most growers will use carbonate based liming materials as these are most commonly available. Commercially sold products tend to be calcitic (only contains Ca) or dolomitic (contains both Ca and Mg). Sometimes blends are created to provide specific ratios of Ca to Mg. The type that is used is decided by the amounts of exchangeable Ca and Mg in the soil. In sugarcane, dolomitic lime is typically advised where the soil Mg levels is <50 mg/L. Suppliers must be able to provide specifications so you can ensure the product meets the minimum requirements as specified by the regulations. Sometimes suppliers will blend slaked or hydrated limes with carbonate limes. Ensure product test results are available to allow for suitable liming rate adjustments depending on the neutralising capacity of the lime.

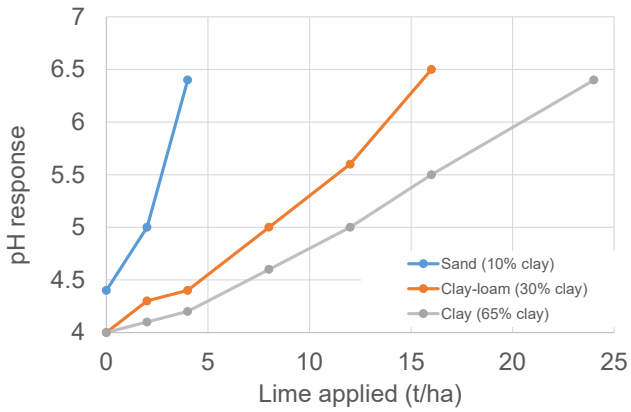
Calcium silicates and other industrial by-products

Calcium silicate minerals and furnace slags are sometimes used as liming materials, often where additional silicon is desired in the soil. Like carbonate limes, they have low solubility in neutral and alkaline conditions, while their CCE tends to be lower than that of carbonate limes. Top-dressing without incorporation of these products is not advised as they often form crusts on the soil surface. Sometimes ashes (fly ash, bag ash) from boilers are also sold as liming materials. Due to the variable composition of materials from industrial processes, testing for neutralising value, nutrient levels and heavy metals should be undertaken before using the material.

Soil and management factors controlling the effectiveness of liming materials

Soil clay content

Soils differ markedly in their response to liming. This is largely due to the buffer capacity of the soil. Buffer capacity is an indication of how easily the acidity in the soil can be neutralised by liming materials. Sandy soils with low organic matter levels have lower buffer capacity than high clay and organic matter soils. Sandy soil thus reacts faster to smaller applications of lime, while high clay soils will require more lime to achieve the same level of acid neutralisation. On the other hand, it will generally take longer for a high clay soil to re-acidify than a sandy soil.



Soil moisture and temperature

For lime to react with soil acidity, adequate moisture must be available. In dry soils, the reaction rates are substantially reduced which means longer periods are required for proper acidity amelioration. Similarly, in cold conditions, the reaction rates decrease, thus slowing the rate of amelioration.

Placement

The general intent with liming is to treat a large volume of soil to permit the roots to have better access to the full soil volume. Due to the low solubility of lime which limits its movement into the surrounding soil, it is usually advisable to uniformly surface apply (even distribution) the lime then thoroughly incorporate the materials into the soil by ploughing or rotary tilling. For sugarcane, this should be done to at least 20 cm depth. This improves the distribution of particles that can react with soil acidity thus providing greater acidity neutralisation of the soil where most of the roots grow. Banding (or furrow application) is usually not advised due the localised effect this has on soil pH. Where this is undertaken to save costs, the benefit is typically short-lived and will require repeating (which is problematic in a ratoon crop).

Topdressing (as might be done in ratoon cane or no-till crops) of lime has limited value in the short term (due to the low mobility into the soil profile). Over several years (>5 yrs) top dressed lime will slowly migrate into the top 20-30 cm of loamy soils (and this enhanced by soil organism activity). Recent research suggests that co-application of gypsum with lime in top-dress conditions is more effective in the short-term to alleviate topsoil acidity if topdressing without incorporation.
Subsurface application of lime (using modified rippers or custom implements) has been promoted as a method to ameliorate subsoil acidity. However, evidence from field trials suggests that the benefits are often marginal (mostly due to banding effects) and that is seldom economically viable.

Uniform application with thorough incorporation during land preparation is the best approach to ameliorating topsoil acidity.

Timing of application

Sufficient time must be allowed for the lime to react with the soil acidity. A general rule of thumb is to apply and incorporate lime at least six weeks before planting (where there is adequate moisture and warmer temperatures). Where lime is to be winter applied (or high rates are required), the period before planting should be extended to at least 12 to 16 weeks to promote more complete reactions to take place. If a fallow crop is to be grown between replants, it is usually best to ameliorate acidity before planting the green manure crop.

Rate of application

SASRI liming recommendations are based on the requirement to neutralise the exchangeable acidity levels in soil to the target acid saturation level (currently advised as a maximum of 20%). The rate considers both the level of acidity and the buffering capacity of the soil. These properties are best assessed by a soil analysis.

Many growers have started to target lower acid saturation levels (<5%) in their liming practices. Benefits of this include a slowing of the re-acidification rate in the ratoon crops (thus reducing or eliminating the need for topdressing of lime) and increased pH levels for more optimal nutrient availability and soil biological function. Where crop diversification or intercropping is being considered, there are also benefits to crops that are less tolerant of soil acidity than sugarcane.

In top-dress, situations where lime is to be surface applied, there is little value in applying high rates (even if the soil acidity levels indicate the need for a high amount of lime). Apart from the ineffectiveness of the lime to ameliorate the soil acidity, there is also a greater risk of run-off and erosion losses of the lime (especially on steep slopes), this can lead to nutrient immobilisation at the soil surface and promote greater ammonia volatilisation where urea is surface broadcast.

Specialised liming products: Liquid and pelletised limes

These are specialist products often promoted as enhanced efficiency liming materials that require considerably less product to achieve a similar liming effect as conventional liming materials. These products are usually conventional liming products that have been milled very finely (typically with particles size being <0.25 mm and with a large proportion < 0.1 mm). It is often suggested that due to the ultrafine nature of the lime particles they are vastly more effective than conventional limes at reducing soil acidity, thus substantially lower rates can be applied (often a third to a fifth, and up to a tenth, of the conventional lime rates). The extra processing substantially increases the cost of these products but does not reduce the required application rate to control acidity in the bulk soil.

Liquid or suspended lime is where the fine particles are suspended in water, sometimes with clay and other compounds to keep them from settling out (note that carbonate limes are not soluble in water). This may allow for more precise spreading and eliminates dust. However, this type of lime is no more effective than dry lime of the same particle size, thus similar rates will be required. This is usually not economically viable for field crops.

Pelletised lime refers to finely milled lime that has been formed into small pellets (typically two – four mm) with an organic, water soluble binder (such as lignosulphonates). They have the advantage of being almost dustless and improve ease of spreading. For these pellets to be effective, they should be applied uniformly across the soil surface then allowed sufficient time (with moisture) to disintegrate completely before incorporation. However, if the pellets do not disintegrate completely before they are incorporated into the soil, they behave like large coarse lumps of lime and are thus ineffective (effectively the pellets reduce the surface area in contact with the soil). Even if allowed to completely disintegrate before incorporation, the effectiveness is still no better than conventional lime of similar particle size, thus the rates required for proper acidity control are like those of good quality conventional limes and thus not economical.

For more information on soil acidity and gypsum ameliorants and how to use them see Information sheet 6.4 Managing soil acidity and 6.6 Gypsum materials and their use. For guidance on sampling for soil acidity see Information sheet 7.16: Soil sampling procedures.

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