Feed the Future Tanzania Kilimo Tija Activity

Technical Bulletin: Liming

INTRODUCTION

This technical bulletin provides comprehensive guidance on the practice of liming, which involves applying lime, also known as agricultural lime or limestone, to soil to reduce acidity and improve soil fertility. The information presented here aims to assist government extension agents, private sector stakeholders, and Tanzanian farmers in enhancing their farming practices and achieving optimal crop production.

SOIL ACIDITY AND HOW IT AFFECTS AGRICULTURAL PRODUCTION

Soil acidity is determined by measuring the activity (concentration) of hydrogen (H+) in the soil solution. It is expressed by a parameter called hydrogen potential (pH), which is a logarithmic expression. The practical meaning of the logarithmic expression of pH values is that each unit change in pH corresponds to a 10-fold increase in the amount of acidity or basicity of the soil. In other words, a soil with pH 5.0 has 10 times more active hydrogen than a soil with pH 6.0. This has enormous significance in crop nutrition and effective fertilizer management. The term pH defines the relative acidity and basicity of a substance. The pH scale covers a range from 0 to 14. A pH value of 7.0 is neutral. Values below 7.0 are acidic and values above 7.0 are basic.

There are several causes of soil acidity, including:

- Parent rock from which the soil was formed.
- Rainfall, as it leaches basic nutrients such as calcium and magnesium.
- Plants, as they take up cations (potassium, calcium, magnesium) releasing hydrogen.
- Fertilizers, some of which acidify the soil (Examples: Ammonium Sulfate and 18-46-0).
- Organic matter.

Very acidic soils are not favorable for the development of most crops, so it is necessary to correct the acidity through liming.

WHAT LIMING IS AND WHAT IT DOES

Liming is the process of applying lime to soil, primarily with the goal of reducing soil acidity and improving soil fertility. Lime is typically in the form of calcium carbonate (agricultural lime) or calcium hydroxide (hydrated lime). When applied to the soil, lime reacts with the soil components and water, altering its pH and providing essential nutrients to plants. It raises the soil pH, making it more favorable for crop growth. Additionally, lime supplies calcium and magnesium to plants and improves the availability of other nutrients already present in the soil.

Fig. 1: Field with lime
Photo: Fintrac Inc.

IMPORTANCE OF LIMING IN TANZANIAN FARMING

Liming is particularly crucial in the context of Tanzanian farming due to several reasons:

a) **Soil Acidity:** Many soils in Tanzania are naturally acidic, with pH levels below the optimum range for most crops. Acidic soils hinder nutrient availability, restrict root development, and reduce crop productivity. Liming helps to alleviate soil acidity, creating a more favourable environment for plant growth.
b) **Nutrient Imbalance:** Acidic soils often exhibit nutrient imbalances, with essential nutrients becoming less available to plants. Liming helps to rectify this imbalance and ensures that crops have adequate access to necessary nutrients, promoting their growth and development.
c) **Sustainability:** By improving soil fertility and nutrient availability, liming reduces the reliance on external inputs such as synthetic fertilizers. This promotes more sustainable farming practices, reduces costs, and minimizes the environmental impact associated with excessive fertilizer use.

Liming acidic soils increases the effectiveness of fertilizers (both the degree of dissolution and absorption efficiency) and minimizes fertilizer loss.

Table 1. Efficiency of Fertilizer Absorption at Different pH Levels

Soil pH	Efficiency			Average Fertilizer Loss
	Nitrogen	Phosphorus	Potassium	
4.5	30%	23%	33%	71.33%
5.0	53%	34%	52%	53.67%
5.5	77%	48%	77%	32.67%
6.0	89%	52%	100%	19.6%
7.0	100%	100%	100%	0%

CHEMICAL CHANGES IN SOIL pH DUE TO LIMING

The lime dissolves and reacts with carbon dioxide to form calcium bicarbonates and hydroxide ions. The hydroxide ion neutralizes soil acidity by combining with hydrogen ions to form water. As the concentration of hydrogen ions decreases, the soil pH increases.

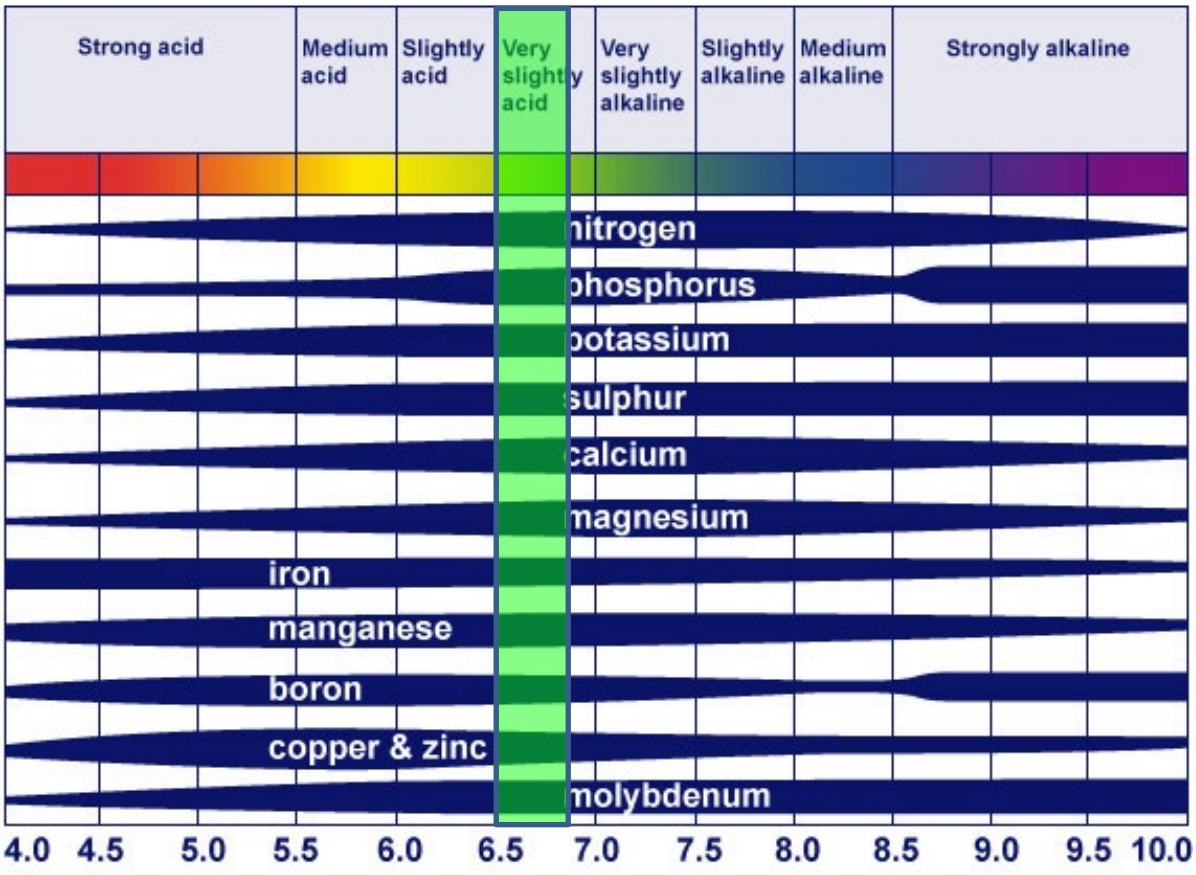
$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + OH^-$$

$$OH^- + H^+ \rightarrow H_2O$$

This increase in pH creates a more favourable environment for soil microorganisms, enhances nutrient availability, and promotes root development. As a result, crops grown in properly limed soils experience improved nutrient uptake and overall growth.

Most horticultural crops thrive in soil with a pH range of 6.5 to 6.8, which provides an optimal balance of available nutrients in the soil. When the soil pH falls below this range, major elements such as potassium (K), phosphorus (P), and nitrogen (N) become less available to plants. Additionally, at pH levels below 5.0, certain nutrients like manganese (Mn) and aluminium (Al) can become toxic. On the other hand, when the soil pH is high, minor elements like iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn) tend to be less available for plants. Maintaining the appropriate soil pH range is crucial for ensuring optimal nutrient availability and minimizing nutrient imbalances in horticultural crop production. Figure 2 below shows how the availability of nutrients changes according to the pH. The ideal pH range for healthy and productive horticultural crops is highlighted in green.

Figure 2. pH Nutrient Availability Chart[1]



BEST PRACTICES IN LIME APPLICATION

Lime can be applied either in solution or in dry form. The dry form is typically preferred due to its cost-effectiveness and long-lasting effects. The amount of lime required for pH adjustment depends on the initial pH level and the desired range. On average, it is recommended to apply 1 to 2.5 tons of lime per acre per year to achieve the desired pH.

a) **Soil Testing:** Before applying lime, it is crucial to conduct a soil test to determine the soil's pH level and the appropriate amount of lime required. Soil testing helps to avoid both under-liming and over-liming, ensuring accurate application rates. Soil samples should be collected from representative areas of the field and sent to a reputable laboratory for analysis. If a lab test is not possible due to financial or other constraints, an alternative option is to use a portable electronic pH meter for rapid/average results. Note that the pH meter will not provide as accurate a reading as the lab test, so lab tests remain the preferred method.

b) **Application Methods:** The two primary methods for lime application are broadcast and localized application. Broadcast application involves spreading lime evenly across the entire field, while localized application targets specific areas or rows where crops are grown. The choice of application method depends on soil conditions, cropping system, and available resources. In areas with known pH variations, localized application may be preferred to target specific acidic spots within the field.

[1] *"pH Nutrient Availability Chart" from Roques et al., 2013.*

c) **Mixing Lime:** Lime should be thoroughly mixed with the soil to ensure even distribution. It can be incorporated into the soil during land preparation or applied as a topdressing, followed by light incorporation. Mixing lime evenly with the soil helps to maximize its effectiveness in adjusting soil pH and enhancing nutrient availability.

d) **Timing:** It is generally recommended to apply lime well in advance of planting, preferably several months before. This allows sufficient time for the lime to react with the soil and adjust pH levels. However, localized applications can be made closer to planting time if necessary. Consult with local agricultural extension services or experts for specific crop and soil recommendations.

FREQUENCY OF LIME APPLICATION

The frequency of lime application depends on soil conditions, initial pH levels, and cropping systems. In most cases, a single application is sufficient for several years. However, periodic soil testing is essential to monitor pH levels over time and identify the need for reapplication. Soil tests should be conducted every 3-4 years or whenever there are changes in crop rotation, soil management practices, or observed decline in crop performance.

PURCHASING LIMING MATERIALS

High-quality lime materials should be purchased from reliable and reputable sources. It is advisable to procure lime from authorized dealers, agricultural input supply stores, or local agricultural extension offices. These sources often provide lime that meets quality standards and can provide guidance on suitable lime products for specific soil types. Farmers should look for quality assurance labels, certifications, or recommendations from agricultural experts to ensure the authenticity and effectiveness of the lime products.

Fig. 3: Front of lime bag

Fig. 4: Back of lime bag


Fig. 5: Training with agricultural lime

Photos in Figs. 3-5: Fintrac Global

MITIGATING LIME APPLICATION RISKS

a) **Counterfeit Products:** To mitigate the risk of counterfeit lime products, farmers should purchase lime from reputable sources and authorized dealers. Avoid purchasing from unknown or unverified sellers, as they may supply substandard or counterfeit products. Check for quality assurance labels, certifications, or recommendations from agricultural experts when making lime purchases.

b) **Health Risks:** Lime can cause skin and eye irritation, so it is crucial to take appropriate safety precautions during the application. Farmers and workers should wear protective clothing, including gloves and goggles, when handling lime. Avoid inhaling lime dust by using a dust mask or working in a well-ventilated area.
c) **Over-liming:** Excessive liming can lead to an excessively high pH level, which may cause nutrient imbalances and negatively impact crop growth. To avoid over-liming, follow soil test recommendations for lime application rates. Soil testing provides guidance on the appropriate amount of lime needed to adjust pH levels effectively. Additionally, retest periodically to ensure the soil pH remains within the desired range.

CONCLUSION

Liming is a valuable practice for Tanzanian farmers to reduce soil acidity and improve soil fertility. By understanding the benefits, appropriate application methods, and associated risks, farmers can effectively utilize lime to enhance crop productivity and achieve sustainable agricultural practices. Regular soil testing, careful selection of lime sources, and adherence to recommended application rates are crucial for successful liming practices. Embracing liming as part of agricultural management strategies can contribute to improved yields, soil health, and long-term agricultural sustainability in Tanzania.