Liming Materials

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ABSTRACT

The pH of the soil is a critical factor in determining whether plants can access vital nutrients or not. Introducing liming materials can reduce soil acidity while bettering the environment for plant growth. Liming materials are an essential tool in contemporary farming and gardening, boosting output, long-term viability, and the lasting wellness of the soil. They can effectively optimize the state of the soil, accessibility of nutrients, and plant health.

Keywords: *Liming materials, soil health, yield, sustainability, soil pH*

I. INTRODUCTION

In agriculture and gardening, liming products, commonly referred to as agricultural lime or soil supplements, are essential for improving soil quality and fostering healthy plant growth. These substances, which are mostly made of calcium and magnesium elements, are added to soil to change its pH and increase the availability of nutrients. Liming entails increasing the acidic soil's pH because it can be detrimental for many plants to flourish.

The main purposes of liming materials addition are as follows:

1. To ensure that soil conditions are favourable for plant growth to maximize agricultural yields and quality.

2. To increase soil fertility by keeping pH levels in the right range, which encourage the activity of good soil microbes engaged in nutrient cycling and organic material breakdown.

3. To ensure long-term soil health by using liming materials into sustainable agriculture operations.

DEFINITION

Liming materials, often known as "lime," are substances added to soil to increase its pH. To improve soil quality and alter soil pH levels for optimum plant growth, these substances are frequently used to treat soils in farming, vegetable gardening, and landscaping. Liming materials can be synthetic or natural and have a variety of uses in soil management.

II. SELECTION OF LIMING MATERIAL

It is crucial to take your soil's unique requirements into an account when choosing a liming substance, in addition to the desired level of pH for the crops that you want to produce. The pH along with nutrient levels in your soil may be determined by conducting soil testing, which can also assist you choose the right kind and quantity of liming substance to employ. To increase plant development and nutrient availability, liming materials are frequently used to adjust soil pH and minimize soil acidity. Soil pH test can help to choose the right liming substance for your soil.

Soil pH test: Knowing the current pH of your soil is crucial before selecting a liming material. This can be done by utilizing a home test kit to determine the pH of the soil or by sending a sample of the soil to a nearby soil testing laboratories for precise findings. On a scale of 0 to 14, 7 soil pH representing neutrality. Most plants require a soil pH range of 6.0 to 7.5 that is mildly acidic to slightly alkaline.

III. POPULAR AGRICULTURAL LIMING MATERIALS

a) **Calcium carbonate:** The most prevalent kind of lime is calcium carbonate, often known as agricultural lime. It elevates pH without significantly changing the soil's magnesium content and is primarily composed of calcium carbonate.

b) **Dolomite:** It is a type of limestone that contains both calcium and magnesium carbonates. For soils with low levels of both calcium and magnesium, it is advised.

c) **Calcium hydroxide:** Hydrated lime is a high-pH lime product that acts quickly. Because it can quickly elevate pH levels and potentially harm plants if improperly applied, it needs to be used with caution.

d) **Marl**: Marl is a naturally occurring liming substance made of a combination of both clay and carbonate of calcium. It is common in some areas and can be used to enhance the quality of soil.

e) **Shell-Based Lime**: Some coastal areas employ crushed shells, such as crushed oyster shell or other type of shells lime. These materials can serve as a local supply of lime since they are high in calcium carbonate and found to be effective in improving structure of sodic clay soils.

f) **Pelletized lime:** Lime that has been pelletized is more practical and simpler to apply than regular lime that has been powdered. Typically, it is constructed of finely ground limestone.

g) **Gypsum (Calcium Sulphate Dihydrate, $CaSO_4 \cdot 2H_2O$):** In the conventional sense, gypsum is not a liming material, but it is frequently used as a soil additive to boost soil fertility and structure. Although it does not affect the pH of the soil, it can be especially helpful in soils with challenges related to compaction, excessive clay content, or poor drainage. Gypsum enhances water infiltration and soil aeration, making it simpler for roots of plants to absorb nutrients and water.

IV. APPLICATION

Method of application: The surface of the soil should be evenly covered in lime. If you have a small area, you can spread it by hand or with lime spreader. When applying lime, stick to the suggested application rate, and wear the proper safety equipment because lime can be caustic.

Rate of application: It is crucial to apply liming materials properly since improper application might result in pH levels that are too high and may disturb the balance of nutrients. According to your condition of the soil and crop requirements, it is essential to adhere to local agricultural extension suggestions and guidelines for liming.

V. LIMING MATERIAL QUALITY CHECK

It is crucial to assess the liming materials' quality to make sure they adhere to the necessary standards and fulfil their intended function of modifying soil pH and enhancing soil quality. The following actions can be taken to evaluate the quality of liming materials:

a) Source:

Pick a trustworthy vendor: Buy liming supplies from a dependable vendor, like an agricultural supply company, or a business that specializes in soil supplements.

Request product information: Ask for thorough details regarding the liming substance, such as its origin, make-up, and certifications related quality, it could possess.

b) Neutralizing value (NV): The liming material's capacity to neutralize acidity is measured by its neutralizing value. Greater neutralizing capacity is indicated by higher neutralizing values. The Neutralizing value should be stated on the product label.

Table. 1. Neutralizing value of CCE (Calcium Carbonate Equivalent) (%)

Liming material	Neutralizing value
CaO	150-175
$CaCO_3$	100
$CaMg\ (CO_3)_2$	95-108
$CaSiO_2$	50-70
$Ca\ (OH)_2$	120-135

Source: Ganeshamurthy *et al.,* 2016

c) Fineness: Liming materials' reactivity may vary depending on their particle size. Materials that are finely ground interact with the soil more quickly. Verify whether the product label includes information about the grind's fineness or not.

Table.2. Liming materials' fineness

Material passing through	Efficiency rating
100 mesh sieves	50%
60 mesh sieves	60%
20 mesh sieves	95%
8 mesh sieves (do not pass)	Ineffective

Some important formulae to calculate liming materials' efficiency:

Fineness × NV÷100= Efficiency

Spread cost ×100÷ Efficiency= Comparative cost

d) Calcium and magnesium content: You can select either lime which is rich in calcium or dolomitic lime or which contains both calcium and magnesium, depending on the requirements of your soil. Make sure the liming substance you select meets the needs of your soil.

e) Calcium Carbonate Equivalent (CCE): CCE compares the liming substance's efficiency to that of calcium carbonate in its purest form. The CCE % should be displayed on the label. The ability of the substance to increase soil pH is indicated by higher CCE values.

VI. EFFECTS

a) Soil pH:

- **Raising Soil pH:** Applying liming materials is primarily done to increase the pH of acidic soils. Acidity in the soil is neutralized by lime by reacting with acidic elements like hydrogen ions (H^+) to produce water and carbon dioxide. The soil becomes more alkaline and less acidic as a result of the rise in pH.
- **Soil Buffering Capacity:** Higher buffering capacity soils can withstand pH shifts, requiring more lime to raise pH in comparison to lower buffering capacity soils. Clay and organic-rich soils typically have greater buffering power.
- **Reaction Time:** It takes time for lime to effectively elevate the pH of the soil. The whole pH correction may not happen for a few months to a year. Because of this, it is crucial to prepare and apply lime before planting crops or creating a garden.

b) Nutrient availability:

The availability of vital nutrients to plants depends on the pH of the soil. In a little acidic to neutral soils (pH 6.0 to 7.0), most nutrients are more easily absorbed by plants. A pH that is too high might cause nutrient shortages, particularly in micronutrients like manganese and iron.

c) Toxicity of nutrients:

- **Reduced Aluminium Toxicity:** Aluminium poisoning can be a concern for plants in acidic soils. By increasing pH, lime application can lessen the toxicity of aluminium, making it less soluble and, hence, less poisonous to plant roots. Through increased root penetration, this may enhance the growth of plants and development of roots, indirectly enhancing soil structure.

d) Soil structure:

- **Aggregate Stability**: The stability of soil aggregates can be improved by lime. The soil structure is greatly influenced by soil aggregates, which are groups of bonded soil particles. By encouraging flocculation of clay particles and preventing the dispersion of soil colloids, lime can increase

aggregate stability. Larger, more durable aggregates may form as a result, enhancing soil structure and water infiltration.

- **Microbial Activity**: Lime can affect the microbial activity in the soil. While excessive lime application may limit some soil microbes, adequate lime application may promote the growth of advantageous soil bacteria. Through the creation of aggregates rich in organic matter, these microorganisms contribute to the breakdown of organic matter and aid in the development of soil structure.
- **Flocculation**: Clay particles can be encouraged to form larger clumps by lime by encouraging the flocculation of these microscopic particles. By expanding pore spaces and boosting water penetration and aeration, this may improve soil structure.

e) Environment:

Liming substances used in farming and gardening techniques can have positive as well as negative impacts on the environment. The kind and quantity of lime utilized, along with the environmental situation, all influence these outcomes.

The following are some few potential negative effects of liming materials on the environment: -

Positive Effects:

- **Improved Soil Health**: In acidic soils, lime can assist in restoring the pH equilibrium, which can enhance the health and fertility of the soil. Better plant growth and maybe improved soil carbon sequestration may result from this.
- **Reduced Aluminium Toxicity**: Applying lime to acidic soils can lessen aluminium's solubility and toxicity, which is good for plant health and can stop aluminium from leaching into groundwater.
- **Enhanced Nutrient Availability**: Lime can increase the availability of vital nutrients to plants by bringing up the pH of the soil. This may lessen the requirement for synthetic fertilizers, which, when used excessively, may have an adverse effect on the environment.
- **Carbon Sequestration**: By encouraging stronger plant development, which in turn causes an increase in the buildup of organic matter in soils, lime can indirectly aid in the sequestration of carbon.

Negative Effects:

- **Impact on Aquatic Ecosystems**: Lime application errors or overapplication can cause runoff into surrounding water bodies. By altering the pH equilibrium and potentially causing harm to aquatic life, high pH levels in water can damage aquatic ecosystems.
- **Ammonia Emissions**: The application of lime may occasionally result in higher atmospheric ammonia emissions. This may be a factor in the development of acid rain and air pollution.
- **Energy Intensity**: Lime production and delivery can be energy-intensive processes that, if not handled properly, can increase greenhouse gas emissions.
- **Calcium Buildup**: Calcium ions may build up in the soil as a result of overusing lime. This may have a negative effect on the availability of other crucial components for plant growth as well as the balance of nutrients.
- **Altered Soil Microbial Communities**: Microbial populations in soil can be affected by lime. In contrast to excessive lime use, which can disturb microbial populations and potentially influence nutrient cycling and soil health, moderate lime applications may promote beneficial bacteria.
- **Loss of Native Plant Diversity**: When lime is applied, the soil's chemistry may occasionally change in a way that favours invasive or non-native plant species than native ones, which could have an impact on the biodiversity of the area.

It is crucial to use the recommended application rates determined by soil testing and consider variables like soil type, climate, and local laws to limit the detrimental effects of liming materials on the environment and optimize their positive effects. The use of lime in a responsible manner, sustainable farming methods, and good soil management can all contribute to maintaining a balance between enhancing soil quality and reducing unfavourable environmental effects.

VII. LIME REQUIREMENT (LR)

Calculating lime requirement involves determining the amount of agricultural lime (usually calcium carbonate or dolomitic lime) needed to adjust the pH of a specific soil to a desired target pH level. The calculation considers the soil's initial pH, the target pH, the buffering capacity of the soil, and the type of lime being used. It is also necessary to ensure periodically that soil will remains at the pH within the target range, as soil pH can change over time. By a study on incubating soil-limes, SMP method was

introduced into the world since 1961 by using 14 acidic soils from Ohio (Shoemarker, *et al.,* 1961).

However, the accuracy of SMP method procedure, depends on its calibration of decreasing soil–buffer pH values and increasing LR rates. Originally, this procedure is especially suitable for estimating the LR on soil needing LR >4:5 Mg ha^{-1} and having pH <5.8 and organic matter content of <100 gram per kilogram (McLean, 1982). The SMP single-buffer method was modified by vang Lierop in 1990 to increase its precision at low LR values and suggested the quantity of lime needed for achieving pH levels of 5.5, 6.0, 6.5, and 7.0 (Table.3.).

Table.3. Relationships between Soil SMP-Buffer pH and Lime Requirement Values to achieve pH 5.5, 6.0, 6.5, and 7.0 of Mineral Soils

	Quantity of liming material required to reach desired pH (Mg ha^{-1})			
Soil–buffer pH	**5.5**	**6.0**	**6.5**	**7.0**
6.9	0.5	0.6	0.7	0.9
6.8	0.6	1.0	1.2	1.5
6.7	0.7	1.4	1.8	2.2
6.6	0.9	1.8	2.5	2.8
6.5	1.2	2.3	3.3	3.6
6.4	1.6	2.9	4.0	4.4
6.3	2.0	3.5	4.9	5.2
6.2	2.5	4.2	5.7	6.0
6.1	3.1	4.9	6.6	7.0
6.0	3.8	5.6	7.5	8.0
5.9	4.5	6.5	8.5	9.0
5.8	5.3	7.3	9.5	10.0
5.7	6.1	8.2	10.5	11.2
5.6	7.0	9.2	11.6	12.4
5.5	8.0	10.2	12.7	13.6
5.4	9.1	11.3	14.0	14.9
5.3	10.2	12.4	15.0	16.2
5.2	11.4	13.6	16.2	17.6
5.1	12.7	14.8	17.5	19.0
5.0	14.0	16.1	18.8	20.4

4.9	15.5	17.4	20.1	22.0	

Source: Van Lierop (1990)

It is important to follow the recommendations provided by the soil testing laboratory to avoid over-liming, which can lead to excessively alkaline soil, or under-liming, which will not sufficiently adjust the pH. Proper soil pH management is crucial for healthy plant growth and maximizing crop yields.

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