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Dolomite as an Acid Soil Ameliorant: A Review on Its Role in Improving Soil Health and Crop Productivity

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Soil acidity is a major constraint to agricultural productivity in many parts of the world, particularly in tropical and subtropical regions. In India, acid soils occupy a significant portion of the cultivated area, with eastern and northeastern states being the most affected. Odisha alone accounts for a large share of acid soils, where crop production is severely limited due to low soil pH, aluminium toxicity, phosphorus fixation and deficiencies of essential base cations such as calcium and magnesium. These constraints adversely affect root growth, nutrient availability, microbial activity and crop yield.

Amelioration of acid soils through liming is a widely accepted practice for improving soil fertility and crop productivity. Among different liming materials, dolomite [$CaMg(CO_3)_2$] has gained importance due to its dual function of neutralizing soil acidity and supplying both calcium and magnesium. Several research studies conducted across different agro-ecological regions of India have reported significant improvement in soil pH, reduction in exchangeable aluminium, enhanced nutrient availability and improved crop performance following dolomite application. Case studies in crops such as rice, maize, wheat, groundnut and banana have demonstrated higher yield, better growth attributes and improved soil biological activity under dolomite-treated soils.

This review highlights the extent and problems of soil acidity, the need for liming, the mechanism of dolomite action and its role in improving soil health and crop productivity. The review emphasizes the potential of dolomite as an efficient, economical and sustainable acid soil ameliorant, particularly for acid soils of Odisha and similar agro-ecological regions.
Keywords: Acid soils, dolomite, liming, aluminium toxicity, crop productivity

Introduction

Soil acidity is a widespread problem affecting agricultural lands across the globe, especially in regions with high rainfall and intensive weathering. Acid soils are characterized by low soil pH, high concentration of hydrogen and aluminium ions and low base saturation. These soils pose serious limitations to crop growth due to nutrient imbalance, aluminium and manganese toxicity and reduced microbial activity. Continuous leaching of basic cations such as calcium, magnesium and potassium further aggravates the problem. In India, soil acidity is predominantly observed in the eastern, northeastern and southern regions, where rainfall-induced leaching and intensive fertilizer use accelerate soil acidification. The problem is particularly severe in rainfed and upland ecosystems, where soil management interventions are often limited. Sustainable management of acid soils is therefore essential for improving soil fertility, crop productivity and livelihood security of farmers.

Extent of Acid Soils in India and Odisha

Acid soils occupy approximately 49 million hectares in India, representing a significant challenge to sustainable agricultural production. States such as Odisha, West Bengal, Assam, Jharkhand, Meghalaya and parts of Chhattisgarh are severely affected. These soils are mainly distributed in regions receiving annual rainfall above 1200 mm. In Odisha, more than 70 per cent of cultivated soils are acidic, predominantly belonging to Inceptisols and Alfisols. These soils are characterized by low pH, low organic carbon, low base saturation and high exchangeable aluminium. Acid soil prevalence in Odisha has been identified as one of the major factors responsible for low productivity of cereals, pulses and oilseeds, despite favourable climatic conditions.

Problems Associated with Soil Acidity

Soil acidity affects crop growth through multiple mechanisms. Aluminium toxicity is one of the most serious constraints, as Al^{3+} interferes with root elongation, cell division and nutrient uptake. Restricted root growth reduces water and nutrient absorption, leading to poor plant establishment and reduced yield. Acid soils also promote phosphorus fixation by aluminium and iron oxides, resulting in low phosphorus availability even under adequate fertilizer application. Deficiencies of calcium and magnesium are common due to leaching losses, while micronutrient toxicities such as manganese toxicity may occur at very low pH. Additionally, soil acidity reduces microbial activity, enzyme functions and organic matter decomposition, thereby affecting nutrient cycling and soil biological health.

Need for Liming in Acid Soils

Liming is an effective soil management practice used to neutralize soil acidity and improve soil fertility. Application of liming materials increases soil pH, reduces exchangeable aluminium, improves base saturation and enhances availability of essential nutrients. Liming also improves soil physical properties and stimulates microbial activity, leading to better root growth and nutrient uptake. However, the efficiency of liming depends on the type of liming material, rate of application, particle size and method of incorporation. Selection of an appropriate liming material is therefore crucial for effective acid soil amelioration.

Dolomite as a Liming Material

Dolomite is a naturally occurring carbonate mineral composed of calcium and magnesium carbonates. Unlike calcitic lime, dolomite supplies both calcium and magnesium, making it particularly suitable for magnesium-deficient acid soils. Magnesium plays a vital role in chlorophyll formation, enzyme activation and photosynthesis, and its deficiency can severely affect crop growth. The use of dolomite helps in correcting soil acidity while simultaneously improving the Ca:Mg balance, which is essential for optimal plant nutrition. In regions where magnesium deficiency is widespread, dolomite has been found to be more effective than calcitic lime in improving crop performance.

Mechanism of Dolomite Action in Soil

The effectiveness of dolomite in acid soil amelioration is attributed to its chemical reactions in soil. Upon application, dolomite dissociates to release carbonate ions, which neutralize hydrogen ions and increase soil pH. Calcium and magnesium ions released from dolomite replace aluminium ions from the exchange complex. The displaced aluminium precipitates as insoluble aluminium hydroxide, thereby reducing aluminium toxicity. Improved soil pH enhances availability of phosphorus and other nutrients and creates a favourable environment for microbial activity. The gradual dissolution of dolomite also provides a sustained liming effect, particularly when finer particle sizes are used.

Effect of Dolomite on Crop Growth and Yield: Case Studies

Several studies have reported positive effects of dolomite on crop performance under acid soil conditions. In rice, application of dolomite at appropriate lime requirement levels resulted in significant improvement in plant height, tiller number, grain yield and straw yield. Research findings have indicated that dolomite @ 0.75 LR produced higher yield and better economic returns compared to calcitic lime, highlighting its superior performance under acidic conditions. In wheat and maize grown on acid soils of eastern India, dolomite application improved soil pH, reduced aluminium toxicity and enhanced nutrient uptake, leading to increased biomass production and grain yield. Improved root growth under dolomite treatment was identified as a key factor contributing to higher productivity. In groundnut, dolomite played a crucial role in improving calcium availability in the pegging zone, which is essential for pod development. Studies have reported improved pod yield, shelling percentage and kernel quality under dolomite-treated soils. Similarly, in banana, application of dolomite either alone or in combination with sulphur significantly improved finger length, breadth and average finger weight. Split application of dolomite was found to be more effective in sustaining soil pH and nutrient availability throughout the crop growth period.

Effect of Dolomite on Soil Biological Activity

Dolomite application has been reported to enhance soil biological activity by improving soil pH and reducing aluminium toxicity. Increased dehydrogenase activity under dolomite-treated soils indicates improved microbial metabolism and overall soil health. Improved microbial activity enhances decomposition of organic residues and nutrient mineralization, thereby contributing to sustained soil fertility. Integration of dolomite with organic manures further enhances soil biological properties by providing additional carbon substrates for microbial growth. Such integrated approaches are particularly important for maintaining long-term soil health in acid soils.

Research Gap and Future Scope

Despite the wide occurrence of acid soils and availability of dolomite resources in India, particularly in Odisha, systematic crop- and system-based studies on dolomite are limited. Long-term experiments evaluating the combined effects of dolomite with integrated nutrient management practices are required to develop region-specific recommendations. Further research is also needed to assess the residual effects of dolomite, its interaction with fertilizers and its role in improving soil biological properties under different cropping systems.

Conclusion

Dolomite is an effective and sustainable liming material for amelioration of acid soils. Its dual role in neutralizing soil acidity and supplying calcium and magnesium makes it superior to conventional liming materials in many acid soil conditions. Application of dolomite improves soil chemical and biological properties, enhances nutrient availability and increases crop productivity. Considering the extensive acid soil area and availability of dolomite in Odisha, its judicious use can play a significant role in improving soil health and agricultural sustainability.

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