

UNLOCKING AGRICULTURAL POTENTIAL MASTERING CALCAREOUS SOIL MANAGEMENT IN INDIA

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Introduction

According to food and agriculture organization (FAO), calcareous soils refers to those soils having 15% or more of free calcium carbonate in any horizon in various forms like powders, concretions, nodules, crust etc. When the zone of calcium carbonate accumulation coincides with crop root zone, there arises several issues in crop production.

Calcareous soils accounts for more than 30% of global land area and in India it occupies more than 60% of total geographical area. These soils are more prevalent in the arid and semi-arid regions due to improper leaching. It can be also observed in humid climates as well when the parent material is rich in calcium carbonate. It can also develop by long term irrigation with water containing dissolved calcium carbonate. In India they are observed in the states of Rajasthan, Gujarat, Punjab, Haryana, Uttar

Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and parts of Madhya Pradesh and Bihar and some union territories.

Calcareous soils needs to be managed for optimum crop productivity and sustainability. While these soils offer certain benefits, they also pose unique challenges that can hinder crop productivity if not managed effectively. Understanding and mastering the management of calcareous soils is key to unlocking their agricultural potential and ensuring sustainable farming practices in India. Characterized by a high pH level, these soils are alkaline due to the presence of calcium carbonate. This alkalinity can impact the availability of essential nutrients to plants, leading to deficiencies in elements like iron, manganese, zinc, phosphorus and boron. The high calcium saturation tends to keep the calcareous soils in well aggregated

form and good physical condition. Calcareous soils uniquely contain carbon in both organic and inorganic forms. This distinctive

characteristic gives them the potential to sequester carbon through proper management, or, conversely, to emit carbon if mismanaged.

Challenges of Calcareous Soils

1. **Low organic matter content:** Calcareous soils are generally low in organic matter and available nitrogen. Organic matter is the key indicator of soil quality and health as they influence the physical, chemical and biological properties of soil.
2. **Nutrient deficiency:** High pH levels in calcareous soils can reduce the availability of certain nutrients to plants. Phosphate, for instance, becomes unavailable due to the formation of calcium phosphates such as apatite. Zinc and iron deficiencies lead to chlorosis (lime-induced chlorosis), significantly affecting crop health and

yield. Additionally, there may be issues with potassium and magnesium nutrition due to the nutritional imbalance between these elements and calcium.

3. **Soil structure and water infiltration:** The presence of calcium carbonate can affect soil structure, making it more prone to compaction. This can reduce water infiltration and retention, affecting the soil's ability to support healthy plant growth.
4. **Salinity issues:** In some cases, calcareous soils can be associated with salinity problems, which further complicates nutrient uptake and affects plant growth.

Effective Management Strategies

To optimize the agricultural potential of calcareous soils, farmers and agricultural experts need to adopt specific management practices tailored to address their unique challenges.

1. **Soil testing and amendments:** Regular soil testing is essential to identify nutrient deficiencies and pH levels. Based on test results, farmers can apply appropriate soil amendments. Adding organic matter, such as compost or green manure, can improve soil structure and nutrient availability. In addition, the organic acid produced during organic matter decomposition reduces alkalinity by neutralizing calcium carbonate in surface and sequestering inorganic carbon in deeper layers. Incorporating acidifying agents like sulphur or gypsum can help lower soil pH and enhance nutrient uptake. Sulphur products used as soil acidifiers to improve calcareous soils, in addition to supplying sulphur as a nutrient, S compounds are also used as soil amendments. The combined application of organic matter along with sulphur had greater effect on overall yield and productivity of crops in calcareous soils as compared to either alone. Soil

conditioners like biopolymer agar or hydrogel, if used according to the established procedures, may increase water infiltration into soil containing clay and prevent soil crusting in calcareous soils.

2. **Balanced fertilization:** Integrated nutrient management by combining adequate amount of chemical fertilizers along with organic manures and biofertilizers are shown to give higher productivity compared to chemical fertilizers alone. Nitrogen fertilizers should be incorporated into calcareous soils to prevent ammonia volatilization. *Azotobacter* and arbuscular mycorrhizal fungi (AMF) inoculation accompanied by organic manure can reduce the reliance on mineral fertilizers while lowering nutrient losses. Inoculation by mycorrhizal or phosphate solubilizing bacteria increased P-supply, which led to improved P uptake. To be effective on calcareous soils, applied phosphorus fertilizer should be in water soluble form. Band application of phosphate is more effective as compared to broadcast application. Application at the time of seeding has been found to be most appropriate since phosphorus is required

mostly during the younger stages of plant growth. Crops planted on calcareous soils may require above normal levels of K and Mg fertilizer for satisfactory nutrition. Addition of organic manures is helpful in lowering pH and also improves the availability of micronutrients. Customized fertilization strategies are crucial for calcareous soils. Using chelated forms of micronutrients, such as iron and zinc, can improve their availability to plants. Foliar sprays of micronutrients are also effective in addressing deficiencies quickly.

3. **Water management:** Efficient water management practices, including drip irrigation and mulching, can help maintain soil moisture levels and reduce the risk of salinity build-up. Proper drainage systems are essential to prevent waterlogging and salt accumulation. Furrow irrigation is better than basin irrigation on slaking calcareous soils. On undulating lands, contour and sprinkler irrigations are better options than flood irrigation.
4. **Crop rotation and cover crops:** Implementing crop rotation with leguminous crops can enhance soil fertility and structure. Cover crops, like clover or vetch, can protect soil from erosion, improve organic matter content, and promote beneficial microbial activity. Also crop residues can be used as mulch or

incorporated into soil rather than it being burned or removed for alternate uses.

5. **Conservation tillage:** Minimizing soil disturbance through conservation tillage practices helps preserve soil structure, reduce erosion, and maintain organic matter levels. This approach also supports the development of a healthy soil ecosystem. Changes in soil physical properties might be expected to develop slowly after the initiation of conservation tillage. However where soils contain an impermeable hard pan (petricalcic horizon) they should be deeply ploughed in order to break the pan. This should be followed by the establishment of an efficient drainage system.
6. **Conservation agriculture:** It is based on three key principles of minimal soil disturbance, permanent soil cover, and crop diversification. Proper adoption of Conservation agriculture (CA) practices can enhance organic matter content of soil, improve microbial activity and crop productivity. Thus CA have been pivotal in enhancing soil health and productivity in regions with calcareous soils while lowering the deleterious effects.

All the above mentioned management practices when implemented scientifically contribute to sustainable land management, thereby minimizing soil pollution and improving soil carbon sequestration.

Success Stories from the Field

Across India, innovative farmers and agricultural experts are demonstrating the potential of effective calcareous soil management. In Rajasthan, for example, farmers have successfully improved crop yields by adopting integrated nutrient management practices and efficient irrigation techniques. Similarly, in Gujarat, the use of gypsum and organic amendments has transformed

previously unproductive lands into fertile fields. In India, the successful implementation of CA on calcareous soils is notably demonstrated in Eastern India. In Bihar, where CA practices led to significant increases in wheat and maize yields while reducing water usage and input costs. Farmers adopting these methods reported better soil fertility and resilience against climate variability.

The Way Forward

As India continues to grapple with the challenges of feeding a growing population and ensuring food security, optimizing the

management of calcareous soils becomes increasingly important. Collaboration between farmers, researchers, and policymakers is

essential to develop and promote sustainable practices that enhance soil health and productivity. Investing in education and training programs for farmers can empower them with the knowledge and tools needed to

Conclusion

Calcareous soils, with their unique characteristics and challenges, offer significant agricultural potential when managed effectively. By understanding their properties and implementing tailored management strategies, India can unlock the productivity of

manage calcareous soils effectively. Government support through subsidies for soil amendments, irrigation systems, and soil testing services can further incentivize the adoption of best practices.

these soils, contributing to sustainable agriculture and food security. The journey to mastering calcareous soil management is not just about overcoming obstacles; it's about seizing opportunities to cultivate a brighter and more bountiful future for Indian agriculture.