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Nutrient Management to Sustain Crop Productivity in Calcareous Soil

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SUMMARY

The management of water and nutrients is the main production challenge. Optimal amounts of water for plant growth have to be provided without wastage, and salts, which may affect plant growth, have to be controlled. Improved fertilizer management is required to grow crops successfully on calcareous soils. To avoid ammonia volatilization, fertilizers containing ammonium-N or urea should be moved into the root zone with rainfall or irrigation, or be incorporated into the soil. For optimal availability of P inoculation with Rizobium or Mycorrhial and foliar application with phosphate fertilizers were used to increase plant growth. Crops planted on calcareous soils may require above normal levels of K and Mg fertilizer for satisfactory nutrition. Using chelated Fe, Zn and Mn deficiencies can be corrected through foliar application of chelates. Adequate K supply and organic matter application can improve the availability of micronutrients. Sulfur products that act as soil acidifiers can potentially improve nutrient availability in calcareous soils by decreasing soil pH. Application of chemical, fertilizers, organic manures and other agricultural beneficial microbes in combination help in nutrient solublization in calcareous soil.

INTRODUCTION

Soil that contain free CaCO3 and effervesce on addition of dilute acids are called calcareous soils. The effervescence is due to the evolution of CO2 from carbonates present in the soil when they come in contact with dilute acids. The carbonates present in the soil are generally in the form of calcium carbonate along with some magnesium carbonate. These soils may contain CaCO3 varying between very minute amounts to more to more than 90%. Those containing minute amount effervesce very feebly whereas, those which have large amount of CaCO3 effervesce very profusely. Calcareous soil shares more than 30% of world soil, and their CaCO3 contents ranges from a few percent to 95% (Marshner, 1995). In India calcareous soil distributed in the state of Rajasthan, Haryana, Gujarat, Punjab, Maharashtra, Uttar Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu and some parts of Madhya Pradesh and Bihar and some union territories (Pal *et al*.2000a). The soil spread over 69.4 % (228.8 M.Ha.) of the total geographical area of India (Pal et al.2000b), the soils have of then more than 15% CaCO3 that may occurs in various forms (FAO,2020). This type of soil normally exists in arid and semiarid regions on account of relatively less leaching. They also found in humid and semi humid regions while. If their parent material is enriched with CaCO3 and are relatively young and has undergone less weathering (Taalab *et al*.2019).

Classification of Calcareous Soil

Calcareous soil classified into four groups as per given by National Bureo of Soil Survey and Land Use Planning.

Class	% of $CaCO_3$
Non Calcareous	Nil
Slightly Calcareous	<5
Moderately Calcareous	5-15
Strong Calcareous	>15

Formation of Calcareous Soil

Calcareous soil are resulted from the following reasons

- The precipitation of $CaCO_3$ from water cover some rivers which contain high amount of $Ca(HCO_3)$
- In sufficient precipitation to leach out all the basic products of weathering, especially the loss readily soluble calcium and magnesium salts, hence they accumulated in the soil
- Calcium is precipitated as calcium carbonate or calcium sulfate and magnesium as magnesium carbonate as the concentration of salts in soil solution increases with weathering.

- As precipitation gradually increases, calcium and magnesium carbonates and sometimes calcium sulfate, accumulated in soil at various depth, depending upon penetration of rainwater.

Chemical Characteristics

- It contains free $CaCO_3$ and some amount of $MgCO_3$ which froth when it come in contact with dilute acid
- Clay and humus colloids contain more than 90 % Ca and Mg as bases, except in the case of calcareous alkaline.
- The pH is always greater than 7 generally near about 8.0 and below 8.4. In the field it varies during different parts of years depending upon the partial pressure of CO_2 is higher. The pH is lower with 0.1% CO_2 the pH of $CaCO_3$ suspension comes down to 7.5.
- The clay minerals of calcareous soils are generally montmorilonite and illite under permanent base saturation conditions.
- The soils are highly buffered in presence of water.

Problems of cultivating calcareous soil:

- Crust formation: The formation of crust is a problem in carbonates rich soils put under cultivation, crusting which takes place at the soil surface higher seedling rate of emergence and percentage.
- Ammonia Volatilization: Ammonia volatilization is more pronounced at high pH.
- Precipitation of Soluble Phosphate: Calcareous soil is having the presence of significant quantities of free excess lime (calcium or magnesium carbonates). Lime dissolves in neutral to acid pH soil but does not readily dissolve in alkaline soil and, instead, serves as a sink for surface adsorbed calcium phosphate precipitation.
- Precipitation of Iron Compounds: according to Lindsay (1995) the total Fe in soil is clearly higher than the soluble Fe required for optimal growth, which is approximately 10^{-8} M in the soil solution. In calcareous soils, the concentration of free Fe^{+++} is extremely low about 10^{-10} M. plants grown in calcareous soils suffer from Fe deficiency and chlorosis.

Availability of plant nutrients

Nitrogen: Calcareous soil, generally do not affect the nitrogen availability to crops. But ammonia volatilization is measure problem in calcareous soil. The alkaline pH values found in calcareous soils affect the rates of N transformations, which in turn can influence the efficiency of N use by plants. Ammonia volatilization is the loss of N to the atmosphere through conversion of NH_4^+ to ammonia gas (NH_3).

Phosphorus: P is most available at pH 6.5 to 7.0, above this pH the PO^{3-} form start to increase over the other two forms and $Ca_3(PO_4)$ thus formed has low solubility. In presence of $CaCO_3$, they generally form carbonate and hydroxyl apatite, which has even lower solubility.

Potassium: Potassium uptake is interrupted in highly calcareous soils even in the presence of enough K salts due to Ca-K ion antagonism. Hence, K uptake is lowered.

Calcium and Magnesium: As both of them are present in free state, their deficiency is not generally encountered in calcareous soil.

Zinc: In calcareous soils Zn may form $Zn(OH)_2$ and also precipitated as $CaZnO_2$ and may be obstructed in $CaCO_3$ crystals also. Thus, the solubility of Zn decreases resulting in its deficiency.

Iron: At the pH of calcareous soil, Fe is present in Fe^{+3} form that is less soluble and hence Fe deficiency occurs

Manganese and Copper: In the pH zone of calcareous soil mostly Mn is found in tetravalent magnetic form that is comparatively less soluble. And at high pH, Cu is mostly held by Ca and Mg clay colloids and has very low solubility, hence availability of Mn and Cu is reduced.

Boron: The availability B is depends upon the availability of Ca. For normal plant growth Ca: B ratio should be between 80: 1 and 800: 1. If the ratio is below 80: 1 there may be B toxicity whereas, if this ratio is greater than 800:1 then there is B deficiency. In the calcareous soil the ratio is wider and deficiency occurs due to its adsorption of $CaCO_3$ surface.

Nutrient Management in Calcareous soil

- The best method to increase the availability of plant nutrients is to increase the CO_2 pressure by any means in order to decrease pH. The CO_2 pressure of soil can be increased by planking, application of bulky organic manures, pressmud and amendments like pyrites. Pyrites (FeS_2) is the best amendments in calcareous soil as it produces H_2SO_4 to dissolve free $CaCO_3$.
- To enhance the availability of N to plant following management strategies is suggested: Nitrogenous fertilizers like ammonium nitrate and ammonium chloride should be used instead of ammonium sulfate and Urea. Ammonical- N and Urea should be incorporated into soil through irrigation and mechanical incorporation. Urea should be applied after coating with S, neem oil or converting into large size granules. Integration of any organics like paddy straw or husk reduces ammonia volatilization. In calcareous soils inoculation by Azotobacter or Bradyrhizobium markedly enhanced all the measured yield components of plants compared to uninoculated crops as well as nitrogen uptake by plants was increased(Ramadan *et al*. 2002).
- Several P management strategies have been found to improve P nutrition for calcareous soil namely: 1. Use of relatively high P fertilizer rates 2. DAP and SSP like soluble phosphatic fertilizers should be used 3. Use of concentrated P fertilizer bands 4. Use of balancing P with other nutrients 5. Use of organic fertilizers like animal manures, crop residues and enriched compost increases solubility of soil native P.
- The potassic fertilizers like Potassium sulfate is used if deficiency of K is detected in calcareous soil.
- Similarly to correct the deficiency of Mg, soil application or foliar application of Mg through magnesium sulfate is recommended.
- The deficiencies of micronutrients are normally corrected through soil and foliar application of chelated elements like Zn, Cu, Fe, Mn and B should be applied wherever necessary and care should be taken that they are not fixed by the soil.
- Sulfur Products Used as Soil Acidifiers: Sulfur products used as soil acidifiers to improve calcareous soils, in addition to supplying sulfur as a nutrient, S compounds are also used as soil amendments. These compounds act as soil acidifiers neutralizing CaCO3 with acid; this, in turn, may lead to a lowering of soil pH and improved nutrient availability. The rates of soil acidifiers required to cause a plant response depend on the amount of CaCO3 in the soil.
- The constraints of all nutrients can effectively managed by adopting integrated Nutrient management strategy, which recommends combine use of chemical, fertilizers, organic manures and other agricultural beneficial microbes help in nutrient solublization.

The doses of which are given in following table.

Micronutrients	Material and doses for application	
	Soil Application	Foliar Application
Zinc	Zinc sulphate (25 kg ha^{-1})	0.5 % zinc sulphate+ 0.25% lime
Iron	Ferrous sulphate (50 kg ha^{-1})	1 % ferrous sulphate+ 0.5% lime
Copper	Copper sulphate (10 kg ha^{-1})	0.1 % copper sulphate+ 0.05% lime
Manganese	Manganese sulphate (10 $kgha^{-1}$)	1% manganese sulphate+ 0.25% lime
Boron	Borax (10 kg ha^{-1})	0.2 % borax

CONCLUSION

Calcareous soil spread over a considerable portion of world including India; In current scenario to feed the continuously growing population the productivity of the calcareous soil is extremely important. Thus, above mentioned limitations and their management practice, development of location specific nutrient management practice is the need of hour.

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