



Calcium as a Plant Nutrient

Rajendra Prasad and Yashbir Singh Shivay*

Division of Agronomy, ICAR–Indian Agricultural Research Institute, New Delhi (110 012), India



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Corresponding Author

Yashbir Singh Shivay

e-mail: ysshivay@hotmail.com

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Abstract

Calcium (Ca) is an essential plant nutrient responsible for the integrity of cells and plant structure, yet it is generally neglected, because it is available in plenty in most cultivated soils. It is therefore not applied as a fertilizer to crops except in groundnut. In acid soils, where it is limiting, it is applied in large amounts as a soil amendment as lime. In sodic soil, where excess of Na creates problems in crop production Ca is applied as gypsum, another soil amendment. When applied in large amounts as lime or gypsum, Ca nutrition is already taken care of and thus there is no need of annual application as a fertilizer. Nevertheless its importance as a plant nutrient cannot be ignored.

Keywords: Acid soils, gypsum, groundnut, lime, plastering, soil amendments

1. Introduction

Among the essential plant nutrients Calcium (Ca) is third in abundance after N and K and is very close to P in abundance in plant tissue. The highest amounts of Ca are found in mitochondria. It is involved in cell division and cell elongation (Helper, 1994). It is a messenger in several developmental and environmental changes (Heintz, 1960; Sanders et al., 2002). It is responsible for cell integrity (Zhang et al., 2018) and therefore in plant survival. Calcium is akin to boron in pollen tube germination and elongation (Wang et al., 2003; White and Broadley, 2003; Prasad et al., 2014; Zheng et al., 2019). Calcium in cells is present as Ca²⁺ ions or as insoluble compounds in association with organic molecules in apoplast. In cell walls it is associated with pectin linkages and is therefore in plant structure. In some plants calcium is present as insoluble crystalline calcium oxalate as a protection mechanism (Prasad and Shivay, 2017). As Ca is relatively less mobile in plants its deficiency is most noticeable on younger leaves or growing points and fruits, which may display dead spots, crinkling, spotting / mottling, small brown spots and stunted growth. Some, well – known Ca deficiency diseases are brown pit in apple, cavity pit in carrots and blossom end rot of bell pepper (Prasad et al., 2016).

2. Physiological Role of Calcium

Calcium is well known for its role in cell division and cell elongation. A large part of the calcium in most plants is located in the leaves and more calcium is present in the older than in the younger leaves. In many plant

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species calcium is present in the form of insoluble crystals of calcium oxalate. Calcium also forms salts with other organic acids and enter into chemical combination with protein molecules. It is important for nitrate reduction in plant tissues (Jena and Rout, 2016).

3. Enzyme Activity

An important function of Ca^{2+} is the activation of a number of enzymes including cyclic nucleotide phosphor-diesterase, adenylate cyclase. Membrane bound Ca^{2+} ATPase and NAD-Kinase which it performs in association with calmodulin. Calmodulin is a polypeptide of 148 amino acids stable and sensitive to pH (Jena and Rout, 2016).

Despite being responsible for so many functions, calcium is never applied as a fertilizer, because it is available in plenty in neutral (pH 7.0) or near neutral soils. However it is present in fairly large amounts in phosphate fertilizers (single and triple phosphate) and in nitrogen fertilizer like calcium ammonium nitrate (Nitro-chalk in Europe). In acid soils (below pH 6.8) and in sodic soils (above pH 8.0) it is applied as a soil amendment in large amounts and Ca nutrition is taken care of. However, Ca is used as a fertilizer in groundnut.

4. Response of Calcium Application in Groundnut

In groundnut, after fertilization, gynophore penetrates the soil and pod develops underground. The calcium requirements are high and the plant roots are not able to absorb and supply enough Ca for the pod development. In a study using labeled Ca, when it was applied as to the fruit zone, 88.3% was absorbed by the fruits and the rest went to other parts of plant, however, when it was supplied in the root zone about 66% was absorbed by the roots themselves (Chahal and Virmani, 1973). Ramachandran and Kulkarni (1992) showed that, while a Ca-saturation of 25% in exchange complex was adequate in sandy soils, heavy clay soils needed a Ca saturation of 75% or more. For acid soils of pH 5.1, 1 t ha⁻¹ lime or 0.3 t ha⁻¹ of gypsum is recommended for groundnut (Raddar and Biradar, 1973). In USA, Carolina's peanut industry, especially the large percentage of Virginia-type peanuts grown, has created a big need for calcium fertilization, commonly referred to as 'land-plastering' (Roberson, 2009).

5. Calcium in Soils

Calcium is the fifth abundant element in earth's crust after O, Si, Al and Fe) and makes up about 3.64% (by weight) of earth's crust (Mengel and Kirkby, 1987). It is present in earth as mineral deposits of calcite (CaCO_3), dolomite (CaCO_3 MgCO_3), gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and apatites or phosphorites $\{3[\text{Ca}_3(\text{PO}_4)_2] \text{CaX}\}$, where 'X' could be F, Cl, OH or CO_3 . Calcium is also a component of silicate minerals viz. anorthite, augite, hornblende and albite (Prasad, 2007). Calcium content in soils depends upon the parent material and weathering. In leached humid tropics it may range from 0.1 to 0.3%, while in calcareous soils it may range from <1% to 25%. In general,

a Ca content of 3% indicates the presence of free calcium carbonate (Jena and Rout, 2016). In soils Ca occurs in three forms, namely, insoluble minerals, exchangeable Ca and Ca in solution. Generally there tends to be an equilibrium between three forms. A large amount of calcium is present as exchangeable Ca on silicate minerals in soils having pH 6.0 or above, it can range from <25 to 5000 mg kg⁻¹ soil. Calcium in soil solution can range from 6 to 778 mg kg⁻¹ soil (Prasad and Power, 1997).

6. Interaction of Calcium with Other Plant Nutrients

Calcium being the base cation in exchange complex of the soil generally positively interacts with most plant nutrients. Among the primary nutrients, Ca interacts positively with N in crop production. However, application of acid forming nitrogen fertilizers, such as, ammonium sulphate, ammonium chloride, ammonium nitrate, anhydrous ammonia and urea deplete soil calcium. To replace Ca depleted due to acid forming nitrogen fertilizers 84 to 148 kg lime (CaCO_3) is required per 100 kg fertilizer (Prasad and Power, 1997). Calcium and phosphorus are supportive of each other and the first phosphate fertilizer made was single superphosphate containing CaH_2PO_4 and CaSO_4 . However in neutral and above neutral soil, when heavy phosphorus applications are made, Ca may be precipitated, but even tri-calcium phosphate is available to crop plants. As regards K, both Ca and K compete for absorption sites and at normal rates of K application only a positive interaction is reported between the two nutrients.

Among the secondary nutrients Ca and S are supportive to each other and that is why gypsum is a preferred fertilizer for groundnut as compared to lime (CaCO_3). Mg and Ca may compete each other for adsorption site on roots and only at very high rates of Mg application it may interfere with Ca nutrition. Dolomite is used as a liming material.

In acid soils, liming helps in removing Fe and Mn toxicity. These two plant nutrients and Al can reach toxicity limits in acid soils. Mukherjee et al. (1947) pointed out the importance of exchangeable Al in soil acidity and Foy (1992) pointed out that in acid soils exchangeable Al did most damage to plants. Heavy liming may however lead to Fe deficiency.

Since both Ca and B are less mobile in plants, they generally support each other in fruit development. Very high Ca uptake may cause B deficiency. A Ca: B ratio of 100–400 is considered for good crop yields (Jena and Rout, 2016).

7. Conclusion

Calcium is an essential plant nutrient but is not needed to be applied every season/year, because it is available in plenty in neutral soils, while in acid soils it is applied in large amounts as lime and in sodic soils it is applied as gypsum. Also it is an important component of some phosphorus and nitrogen fertilizers. However, its application as gypsum or lime (in acid soils) in groundnut at pegging stage is essential for good pod



development.

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