ROLE OF CHLORINE IN COCONUT NUTRITION

NEENU S[1], KARTHIKA K S[2]*, PRABHA SUSAN PHILIP[3], ANIL KUMAR, K S[2]

[1]ICAR- Central Plantation Crops Research Institute, Kasaragod, Kerala
[2]ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, Karnataka
[3]ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Delhi
*Corresponding author, E-mail: kskavukattu@gmail.com

Chlorine, a halogen group element, is one of the essential nutrients required for the growth and development of higher plants (Marschner, 1995). The main sources of chlorine in soil are rain water, sea sprays, volcanoes, irrigation water, fertilizers containing chlorine, dust and air pollution. The concentration of chlorine in rain water varies between 0.4-3000 ppm depending on the closeness of sea or salt lake. In soil and marine environments, around 2000 naturally occurring organo-chlorine compounds are being produced at varying decomposition rate through different natural processes. Human made organo-chlorine compounds like various agricultural chemicals, medical pharmaceuticals, artificial sweeteners *etc.* also contribute chlorine to the soil.

In soil, chlorine exists in the most stable oxidation state as chloride anion *i.e*. Cl^-. Annual chlorine deposition in soil ranges from 1 to >1000 kg per hectare depending upon the nearness to sea and cultural practices in general. Plants absorb chlorine as chloride ions (Cl^-) and floral parts contain the lowest Cl^- concentration compared to other plant parts. The critical concentration of chlorine in plants generally varies between 200-2000 mg per kg of dry weight of plant. It was reported that the minimum chlorine requirement for adequate plant growth in most species ranges between 0.2 to 0.4 mg g^{-1} of dry weight of plant. But in many plant species the average chloride concentration ranges between 2 to 20 mg g^{-1} of dry weight. Even though chlorine is not an essential macronutrient, it is reported to accumulate into macronutrient concentrations in many plants. Since chlorine in macronutrient levels stimulate growth and improve plant performance, in many plants in addition to its role as an essential micronutrient it also acts as a beneficial macronutrient. However, high accumulation of chloride in plants will be toxic and can restrict the crop growth and yield (Xu *et al*., 2000).

MAJOR FUNCTIONS OF CHLORINE IN PLANTS

In plants, chlorine performs many biochemical and physiological functions. It plays an important role in photosynthesis and is a structural constituent of phtotosystem II. It is involved in activation of some enzymes like vacuolar proton pumping ATPase, asparagine synthetase and alpha amylase. The major role of Cl is in maintaining electrical charge balance, improvement of water balance and osmoregulation which regulates the opening and closure of stomata. Since chloride is the main inorganic anion in the vacuole, it determines the vital roles in cell osmoregulatory and turgor driven processes. It is reported that chloride is the most preferred osmoticum and cannot be adequately substituted by any other anionic macronutrients (Franco-Navarro *et al*., 2016; Wage *et al*., 2017). It improves the water storage capacity of plant cells (Xu *et al*., 2000), water use efficiency (Franco-Navarro *et al*., 2016), nitrogen use efficiency in plants and maintains plant immunity (Colcombet *et al*., 2009). In plants like tobacco and pulses, there are reports that chloride treatment lead to cell elongation and this indicates the biological role of chloride in plant growth (Burdach et al., 2014).

CHLORINE NUTRITION IN COCONUT PALMS

The coconut palm (*Cocos nucifera Linn.*), a tropical tree species, popularly known as 'tree of life' provides almost all necessities of life like food, drink, oil, fiber, timber, fuel *etc*. Its natural habitat was the narrow sandy coast where the conditions were ideal for its growth. Coconut is grown in a wide variety of soils ranging from pure sand to clay and from moderately acidic to alkaline. Among that red sandy loam, coastal sandy, laterite and alluvial soils are more suitable. Critical levels of Cl in coconut leaf during different growth stages were found to be 0.70% Cl at nursery stage, 0.60 % Cl at pre-bearing stage, and 0.55 % during bearing stage with optimum leaf Cl as 0.50%; 60% and 55% respectively for nut per palm, copra weight per nut and copra yield per palm (Magat and Margate 1990).

FUNCTIONS OF CHLORINE IN COCONUT PALMS

Chlorine plays certain physiological roles in coconut like in many other plants. In coconut, the major mechanisms in which chloride involves are stomatal opening and closing, stomatal regulation during dry seasons, water balance, acts as an osmoticum in maintaining turgor during drought and its role in splitting of water molecule in photosystem II during photosynthesis. Chloride is very important for regulating the stomatal aperture and managing the water flow between two guard cells and the four subsidiary cells of the coconut stomatal apparatus. (Braconnier and d´Auzac,1990). It forms the dominant physiological counter ion for K^+ in controlling stomatal pore aperture of coconut. Chloride plays a great role in water balance in coconut palms. Chloride improves the quality and shelf life of product and helps increase the shelf life and resistance to pests and diseases.

CHLORINE DEFICIENCY IN COCONUT

Chlorine deficiency is expressed as reduction in growth rate of palms, reduced number of green fronds, reduced number of nut sets, reduced N concentration in leaves, cracking of stems and frequent incidence of stem bleeding, and higher incidence of leaf diseases such as gray leaf blight and leaf spot. Tip of the leaf blades appear dry and exhibit wilting symptoms followed by chlorosis, bronzing and necrosis. Curling of the leaves may also occur. Roots show restricted growth with stubby, club shaped laterals. The older leaves show yellowing or orange mottling and dried up leaf tips and edges (Fig.1 and 2).

Fig.1: Cl deficiency symptoms in coconut palm (wilting of leaves)

Fig.2 Cl deficiency symptoms (drooping of fronds) in coconut palm

Leaves exhibit distinct and abrupt boundaries between the affected and healthy tissue. Severe deficiency may result in bronzing and wilting of leaves typically because of highly branched roots with stubby tips. However, bronzing and wilting are less reliable and other causes should be considered. Chlorine deficient plants have delayed (about 3 h) opening of stomata (Braconnier and d´Auzac, 1990), reduced osmo-regulation capacity of coconut under water stress, drop in stomatal conductance and net assimilation, have unfavorable effect on carbohydrate nutrition of coconut palms during the dry season (Braconnier and Bonneau, 1998).

CHLORINE TOXICITY IN COCONUT

Toxic levels of chlorine in soil will increase the osmotic pressure of the soil resulting in the reduced availability of water to plants and leads to wilting of the plant *i.e.* chloride induced drought occurs. High tissue Cl concentrations (above criticial level) resulted in undesirable effects on growth of coconut seedling by reducing chlorophyll content and assimilation of CO_2. Dieback of terminal axis and small branches may occur with severe toxicity. Symptoms can occur in absence or presence of sodium. Toxicity symptoms can vary with a crop's tolerance to chlorine.

CONCLUSION

Coconut palms need Cl as an essential nutrient mainly in imparting resistance in palms. Hence, application of Cl containing fertilizers may be carried out to overcome the possible deficiency of Cl in soils. However, more than Cl deficiency its toxicity raises more concern worldwide.

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