Current Trends in Biomedical Engineering & Biosciences
ISSN: 2572-1151

Mini Review
Volume 9 Issue 3 -september 2017
DOI: 10.19080/CTBEB.2017.09.555763

Curr Trends Biomedical Eng & Biosci

Aluminium Toxicity in Maize Crop

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Submission: September 08, 2017; **Published:** September 25, 2017

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Abstract

Acid soils are prevalent in most of the north-eastern regions of India which are significantly limiting production of major commercially important crops worldwide. Toxic levels of aluminium that are most widespread in acid soils are the major concerns. The production of majority of food crops, and in particular maize crops, is harshly affected under such acidic conditions. Soil acidity is one of the major constraints to agricultural production in large parts around the world. In acid soils, aluminium toxicity and consequent low phosphorous availability impair plant growth. As per the current situation, there is a need to focus on spirited maize supply chain in surplus with focusing on production and productivity of this crop.

Introduction

Maize is one of the most significant cereal crops of the world. In most of the developing countries maize contributes to the food security. After rice and wheat maize has been emerging as a third most important crop in India. Maize is not only used as human food and animal feed but it is also widely used for corn oil production, corn starch industry, baby corns etc. However, Inspite of the production strength, corn yields in India are considerably below the yields as compared to corn producing countries. But, on the other hand, there is immense scope for an increase in India's corn production by increasing area under hybrids, adoption of better genetics and improved agronomic practices.

Driven by structural changes in agriculture and food consumption patterns, maize is bound to hold its share as an important cereal crop in future. As per the present scenario, there is a need to focus on competitive maize supply chain in addition to focusing on its production and productivity. The adaptability of maize crop is clearly associated to a broad array of environmental conditions and this adaptability is responsible for its far more extensive distribution over the earth in comparison to any other cereal crop. Also the growth of maize has been found at an altitude of around 4000m below sea level. A medium-textured, deep, fertile and well drained soil is ideal for maize cultivation but if well managed the crop could be well grown on wide variety of soils. pH ranging from 5.5-7.0 is optimum for growing maize crop but at pH below 5, the yield of the crop is sharply affected due to high content of aluminium sulphate.

In the Earth's crust aluminium is the most abundant metal and the third most essential element. Aluminium remains incorporated into soil minerals like aluminosilicate and a very small quantity appears in the soluble forms which influence biological systems [1]. In acid soils, however, the release of Al from Al-containing minerals is accelerated, which increases the concentration of phytotoxic forms of Al in the soil and in some farming practices [2].

Root Growth Vs Aluminium Toxicity

In conditions where physiological responses are concerned, it is far more difficult to interpret higher levels of aluminium concentration. Precipitation, complexation or polymerization may lead to inertness of a high fraction of aluminium in the nutrient growth medium. Thus, there is a possibility that the level of free aluminium concentration that is responsible for promoting toxicity can be much lower as compared to that of priorily existing in the growth medium [3]. As far as the tolerant genotypes are concerned, these low concentrations of aluminium may lead to an increase in apical meristem activity [4] resulting in direct root growth stimulation [5]. Soil acidity is one of the major constraints to agricultural production in large parts around the world. In acid soils, aluminium toxicity and consequent low phosphorous availability impair plant growth.

Aluminium stress is primarily visible in the roots. Aluminium stress primarily limits crop production in acid soils [6] due to which significant attention has been focused to assess the effect of aluminium toxicity on cultivated plants. Approximately up to 40% of the world's arable land is occupied by aluminium toxicity [7] and therefore aluminium phytotoxicity may be well thought-out as one of the major limiting factors for production of crops in the world [8]. The dynamic role of aluminium in soils, in relation to plant growth, nutrient uptake, its interaction with cations and anions including organic ligands have been investigated by various researchers. The literature available on various aspects of aluminium is voluminous, suggesting its concern in base unsaturated soil, for crop production.

Role of Aluminium in Soil and Plant

Aluminium occurs mainly in the primary minerals like micas, feldspar, cryolite (Na3AlF6) in the secondary clay minerals and in ore such as bauxite .Aluminium makes up 8.1, 8.2, 2.5 and 0.4 percent of igneous, shales, sandstone and limestone rocks respectively [9]. It is released from octahedral coordination with oxygen in minerals by weathering process. Once released, the trivalent aluminium ion assumes octahedral coordination with six 0H2 group each of which dissociates H+ ion in sequence as the increased [9]. Has described the sequence of dissociation as follows: the resulting hydroxy aluminium ions are adsorbed to the cation exchange sites of the soil. Here, they polymerize on charged surfaces and in the interlayers of the clay minerals obstructing both the contraction of the clay lattice and the exchange of cations. Soil acidity limits plant growth due to a combination of factors including aluminium, manganese and hydrogen ion toxicities and deficiencies of essential elements particularly calcium, magnesium, phosphorus and molybdenum [10]. Reported that at soil pH values <5 soluble aluminium is generally considered to be the most prominent growth limiting factors. The level of aluminium in soil solution will depend upon the soil pH, amount and type of primary and secondary aluminium containing minerals, exchange equlibria with inorganic surfaces and complexation reactions with organic constituents.

Mechanisms of Aluminium Resistance

Because of the agronomic importance, breeding crops with Al resistance has been a successful and active area of research; however, the underlying molecular, genetic and physiological principles are still not well understood. Despite the interest from many researchers, no Al resistance genes have yet been cloned from any plant [11]. It has been known that plants which exist in the presence of potentially toxic Al concentrations must be able to avoid direct contact of vital structures and metabolic processes with high activities of Al3+ ions. The physiological mechanisms of Al resistance can either be mediated via exclusion of Al from the root apex or via intracellular tolerance of Al transported into the plant symplasm [11,12]. Either extracellular precipitation or detoxification of Al3+ may be implied in exclusion.

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How to cite this article: Priyanka Arora, Surabhi Dixit, Geeta Singh , Saurabh Pandey. Aluminium Toxicity in Maize Crop. Curr Trends Biomedical Eng & Biosci. 2017; 9(3): 555763. DOI: 10.19080/CTBEB.2017.09.555763

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