Toxic symptoms of aluminium in plants

A.K.Rath, N. Panda, S. Bhattacharyya*
Department of Botany, School of Applied Sciences (Bolangir Campus), Centurion University of Technology and Management, Odisha, India

Abstract
Aluminium, which is the most abundant mineral on earth crust, can be a major crop limiting factor in acid mineral soils where it attains its exchangeable form. The toxic effect of Al can come within minutes of exposure basically affecting the rhizosphere in plants. Al significantly alters the mineral uptake by plants. Hence, the result is the expression of various toxic symptoms. Plant roots are directly and severely affected by the mineral with a decrease in root length as the primary symptom. In shoot parts, the development of purple colouration and loss of vigour were also noticed including even a change in flower colour. Moreover, cytotoxic symptoms of aluminium were not uncommon. Thus, the negative impacts have a significant role in reducing the crop yield in acid soils. Here, there is an attempt to provide a concise account of the phytotoxic symptoms of aluminium.

Key words*:* Aluminium, Aluminium Toxicity, Crop Yield, Metal, Rhizosphere, Symptoms

Introduction

Aluminum (Al) is a major abiotic stress factor for plants in acidic mineral soils (Lianwen Qian et al. 2018) affecting crop production around the globe (Gupta 2013). Al-Phytotoxicity is expressed primarily by inhibition of root elongation and/or reduction in the uptake of nutrients (Magalhaes et al. 2018; Xiang Zhang et al. 2019). At an acidic pH range, the resulting toxic species of Al^{3+} ligands with the groups like carboxylate, phosphate and sulfate of both soil solution and of the root cells, to hamper cell elongation, cell division and also the intake of essential cations such as K^+, Ca^{2+}, and Fe^{2+} including phosphate anions (Nguyen et al. 2003), Researchers revealed that the calculated activity of the Al^{3+} ion is the single best indicator of toxicity, but reports were also there for toxicity of the monomeric hydroxyl cations $Al(OH)^{2+}$ and $Al(OH)^+$ and again for the polynuclear hydroxy complexes of Al (Foy 1992).Within minutes after exposure to Al^{3+}, the toxic symptoms in the form of retardation of root growth and/or decrease in water and mineral uptake start appearing in roots (Silva et al. 2012). Toxic symptoms of aluminium; either in natural condition or in controlled environment appear at lower pH range affecting morphological, physiological and cytological processes considerably. Also, these symptoms are expressed in terms of various abnormalities in almost all the part of the plants there by limiting the crop yield in different crop species. The review provides an insight into the range of phytotoxic symptoms induced by aluminium.

Major toxic symptoms induced by aluminium

Al-induced symptoms can be reflected as deficiencies of P, Ca, Mg or Fe or even as drought stress (Foy 1988, 1992; Kamprath and Foy 1985). Inhibition of root elongation or root growth is a primary symptom of aluminium toxicity (Frankowski 2016; Kopittke et al. 2016). In some cases, however, the toxic symptoms also include dwarfing of roots (Gunse et al. 2000). Reduction in shoot growth was observed as in rice Fageria (1982), coffee (Braccini et al. 1998) and in barley (Alam 1981). It was a later happening effect, of the negative effect of Al in roots (Larsen et al. 1997). Further, purpling of stem was noticed in some systems (Foy, 1992).Leaf symptoms are more commonly induced by Al. It ranges from curling along the margin to marginal chlorosis (Pavan and Bingham 1982), dark green and prupling of leaves and/or veins, yellowing and death of leaf tips and even collapse of petiole (Foy 1992), leaf necrosis (Nguyen 2003) and a decrease in leaf size (Braccini et al, 1998).

Aluminium induced change in flower colour was reported for the first time by Rath and Behera (2004) in *Brassica* wherein, the normal homogeneous yellow petal was modified to half-yellow half-white type. This notorious element had also altered many other specific functions like nodulation. Decrease nodulation with the damage to root hairs was reported by Kim et al. 1985. Al was found to be toxic to

ISSN: 2395-6216