RESEARCH ARTICLE

ALUMINUM TOXICITY ON THE GERMINATION OF ONION SEEDS

*Raquel Stefanello, Luciane Almeri Tabaldi and Luiz Augusto Salles das Neves

Federal University of Santa Maria, Camobi Campus, 97105-900, Santa Maria, Rio Grande do Sul, Brazil

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INTRODUCTION

Presently, there is great concern about the effects that many chemical pollutants have on the environment and human health, because the growth of industrialization in recent decades has increased the release and concentrations of these potentially toxic compounds in nature. As a consequence, toxic metals such as aluminum (Al) have accumulated in the environment, which is affecting ecosystems and creating environmental problems (Gaetke & Chow, 2003). Aluminum is an abundant element in soils and, depending on the pH, can be available (free) in the form of Al³⁺ in the soil solution. In general, concentrations are low in soils with a pH above 5.5 and high in soils with a lower pH. In relation to Al, a main interest is in the ability of plants to tolerate toxic quantities of this element (Al³⁺). This is genetically controlled and the degree of tolerance differs significantly based on the species and genotype (Furlani, 2004; Rampim & Lana, 2013). Generally, the toxic effect of Al causes severe changes to the structure of roots, including inhibition of root growth, which results in short roots with thicker apices, and few or no root hairs (Gupta et al., 2013). Various studies have been conducted to determine the tolerance of species exposed to Al, for example: Cucumis melo (Nascimento et al., 2010); arugula - Eruca sativa (Santos et al., 2010);

Conyza spp. (Yamashita & Guimarães, 2011); barbados nut - Jatropha curcas (Lana et al., 2013; Machado et al., 2015); rice (Alia et al., 2015; Freitas et al., 2012); corn (Milane et al., 2014) and legume forages - Adesmia latifolia, Trifolium repensand and T. pratense (Scheffer-Basso & Prior, 2015). However, no studies were encountered that have evaluated the toxic effects of Al on the germination of onion seeds. The onion (Allium cepa L.) is one of the most widely cultivated plants in the world and is consumed by almost all people on the planet, regardless of ethnic and cultural origin (Boiteux & Melo, 2004). The nutritional requirements of onion vary among the diverse cultivars and the uptake of nutrients by this species can differ due to soil type, cultivation system and crop cycle (Trani et al., 2014). In addition, the development of the root system is affected by the environment (which influences the shoot of the plant) and physical, chemical and biological factors, such as mechanical impediment, availability of nutrients, temperature, humidity, attacks by pests, and the presence of toxic elements (Taylor & Arkin, 1994). Therefore, it is important to understand the functions of nutrients, the symptoms of deficiencies, toxins, and the forms of absorption and transport of these nutrients and toxins (Trani et al., 2014). Considering that high concentrations of Al negatively affect the germination of seeds, and because it is beneficial to understand the effects of Al on the germination, growth and development of plants (in order to help make sure farms use the correct soil amendments), the aim of this study was to verify the tolerance of onion to aluminum during seed germination.
MATERIALS AND METHODS

Seeds of the onion variety Baia Periforme were acquired from a company that produces and sells seeds. The germination percentage indicated on the package was 85%. To evaluate the toxic effect of the aluminum (Al) on the germination process, the onion seeds were sown on a paper substrate moistened with an aqueous solution of aluminum chloride (AlCl₃) at concentrations of zero (control) 15, 30, 45 and 60 mg L⁻¹. For the control (level zero), only distilled water was used. The toxic effect of Al on the seed germination process was evaluated using the tests listed below (Brasil, 2009):

Germination (%): conducted based on four repetitions of 100 seeds distributed in plastic boxes (gerbox), on germitest paper moistened with distilled water (2.5 times the weight of the paper). After sowing the seeds, the plastic boxes (gerbox) were maintained in BOD chambers at a constant temperature of 20 °C and 8 h of light and 16 hours of dark. Counts were made on days six and 12 (when the test ended).

First count (%): conducted together with the germination test, where the percentage of normal seedlings was determined on day 6 of the test.

Seedlings length (cm): normal seedlings were obtained by sowing four repetitions of 20 seeds. Rolls of paper containing the seeds were kept in a germination chamber for six days, at a temperature of 20 °C. Total length, shoot length and root length of 10 seedlings were randomly evaluated for each repetition using a millimeter ruler. The average length of the seedlings was obtained by adding the number of measurements of each repetition and dividing this by the number of normal seedlings measured.

Dry mass of seedlings (mg): first, the fresh weight of 10 seedlings was measured (four repetitions), which were then placed in paper bags in an oven at 60 °C until the mass was constant (48 h). Subsequently, the seedlings were weighed again using a precision scale (0.001 g). The experimental design was completely randomized, where treatments consisted of different concentrations of the solutions. The data was submitted to an analysis of variance using the F test and, when significant, a regression analysis was performed using the program Sisvar.

RESULTS AND DISCUSSION

The analysis of variance indicated that the total length and root length variables were significantly different for the treatments (Table 1). In the absence of Al, the seeds had averages of 77% and 53% of normal seedlings for the seed germination and first count tests, respectively (Figure 1), and there was no significant reduction in the percentage of normal plants for the highest concentration of Al used (60 mg L⁻¹). Based on this, concentrations to 60 mg L⁻¹ do not affect germination or vigor of onion seeds.
According to Benavides et al. (2005), the phytotoxicity of metals depends on the concentration, plant species, and stage of development, period of exposure, and organ and tissue of the plant. The total length of the onion seedlings decreased as the concentration of Al increased (7.04 cm [control] to 6.79 cm [60 mg L\(^{-1}\)]). The length of the roots also decreased from 2.88 cm for the control to 2.50 cm for the highest concentration of Al (Figure 2A).

However, there was no significant effect on the length of the shoot and dry mass of the onion seedlings (Figure 2B). Even at low concentrations, soluble Al is toxic to most plant species. Studies have demonstrated that this metal is absorbed by the roots, causing phytotoxicity, which primarily influences the growth of cells in the elongation zone of the roots, blocking the mechanisms of absorption and transport of water and nutrients (Rossiello & Jacob-Netto, 2006; Alamgir & Akhter, 2009; Bian et al., 2013). Consequently, less soil is explored and the plants are more sensitive to drought, which prevents them from reaching their productive potential (Castro & Oliveira, 2005). Results similar to those found in this study were found by Santos et al. (2010), who evaluated the effects of Al on arugula plants (Erucia sativa Mill.). These authors observed significant reductions in root, shoot, and total growth, number of leaves, and average dry mass as concentrations of toxic Al increased (to 60 mg L\(^{-1}\)). Machado et al. (2015) and Alia et al. (2015) concluded that exposure to elevated concentrations of Al inhibits the root growth of Barbados nut (Jatropha curcas L.) and rice, respectively. In addition, Malekzadeh et al. (2015) observed a decrease in the shoot and roots of corn seedlings when exposed to high concentration of toxic Al (100 µM).

**Conclusion**

Based on the results, concentrations over 45 mg L\(^{-1}\) reduce the total length and root length of onion seedlings but do not influence germination percentage of the seeds. Therefore, onion seeds are moderately tolerant to Al at the levels tested in this study.

**REFERENCES**


