Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 10, pp.39738-39740, October, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

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

ARTICLE INFO

Article History:
Received 10th July, 2016
Received in revised form
15th August, 2016
Accepted 18th September, 2016
Published online 30th October, 2016

Key words:

Allium cepa,
Germination process,
Aluminum chloride.

ABSTRACT

As a result of human activity, the contamination of water, soil and seeds by potentially toxic metals, such as aluminum (Al), is an obstacle to agriculture. The aim of this study was to verify how onion seeds tolerate aluminum during germination and initial seedling growth. Seeds were placed on paper soaked in an aqueous solution of aluminum chloride at concentrations of zero, 15, 30, 45 and 60 mg L^{-1}. The parameters evaluated were germination percentage, first count, and total length, shoot length, root length and dry mass of seedlings. Concentrations above 45 mg L^{-1} caused a reduction in the total length and root length of the seedlings onion, but did not influence the germination percentage of the seeds. Based on the results, it can be concluded that onion seeds are moderately tolerant to Al levels tested in this study.

Citation: Raquel Stefanello, Luciane Almeri Tabaldi and Luiz Augusto Salles das Neves, 2016. "Aluminum toxicity on the germination of onion seeds.", *International Journal of Current Research*, 8, (10), 39738-39740.

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 Al^{3+} 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 (Al^{3+}). 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.

Corresponding author: Raquel Stefanello,
Federal University of Santa Maria, Camobi Campus, 97105-900, Santa Maria, Rio Grande do Sul, Brazil.

Table 1. Summary of the analysis of variance for the variables germination (G), first count (FC), total length (TL), shoot length (SL), root length (RL) and dry mass (DM) of onion seedlings exposed to different concentrations of aluminum

Source of variation	Degrees of freedom	Mean square					
		G	FC	TL	SL	RL	DM
Treatment	4	41.700	28.175	1.109*	0.046	0.939*	0.038
Residue	15	48.333	21.566	0.245	0.085	0.155	0.020
CV (%)		9.51	9.34	7.09	7.14	13.99	9.53

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 ($AlCl_3$) 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.

The results of this work corroborate what was found by Milane *et al*. (2014), where germination and initial development of corn seedlings were not affected by different concentrations of Al until 75 mg L^{-1}. In addition, Macedo *et al*. (2008) verified that there was no difference in the germination of coffee seeds until 45 mg L^{-1} of Al.

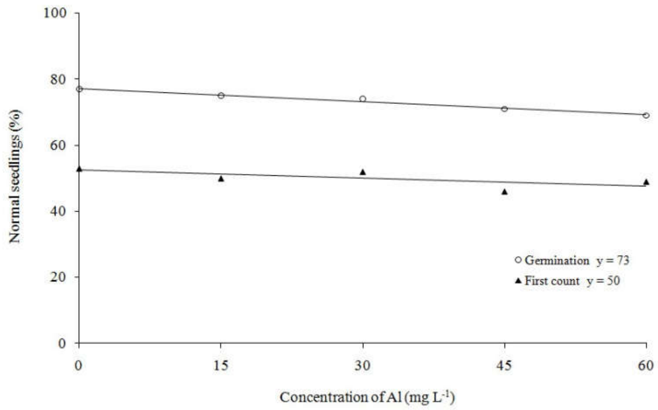

Figure 1. Percentage of normal onion seedlings exposed to different concentrations of aluminum

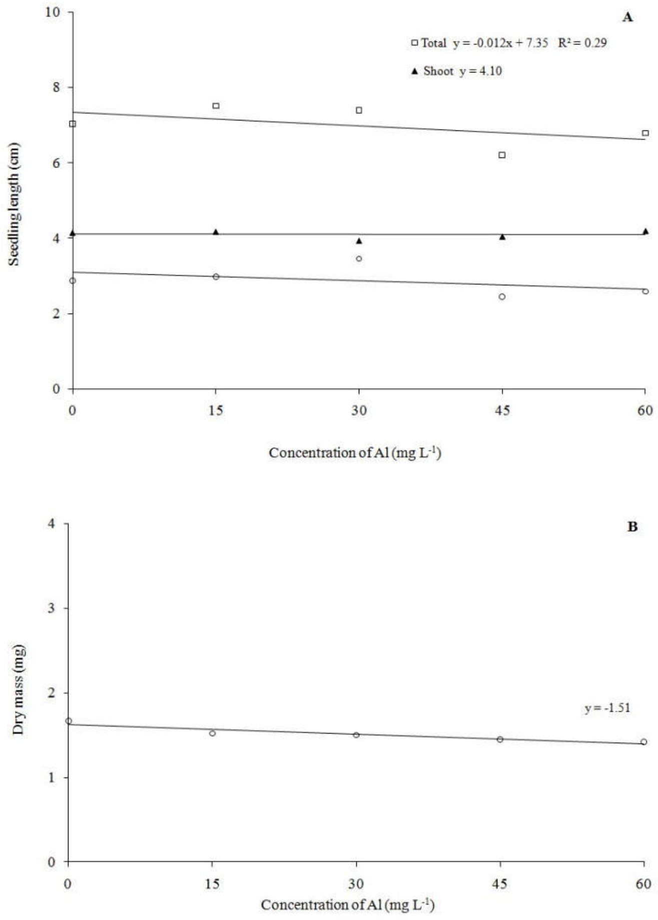

Figure 2. Length (A) and dry mass (B) of onion seedlings exposed to different concentrations of aluminum

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 & Arkhter, 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 (*Eruca 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

Alamgir, A.N.M. and Akhter, S. 2009. Effects of aluminum (Al3+) on seed germination and seedling growth of wheat (Triticum aestivum L.). *Bangl J Bot,* 38(1):1-6.

Alia, F.J., Shamshuddin, J., Fauziah, C.I., Husni, M.H.A. and Panhwar, Q. A. 2015. Effects of aluminum, iron and/or low pH on rice seedlings grown in solution culture. *Int. J. Agric. Biol*., 17:702-710.

Benavides, M.P., Gallego, S.M. and Tomaro, M.L. 2005. Cadmium toxicity in plants. Braz. *J. Plant Physiol*., 17:21-34.

Bian, M., Zhou, M., Sun, D. and Li, C. 2013. Molecular approaches unravel the mechanism of acid soil tolerance in plants. *Crop J*., 1:91-104.

Boiteux, L.S. and Melo, P.C.T. 2004. Taxonomia e origem. In: Oliveira, V.R., Boiteux, L, S. Sistema de produção de cebola (Allium cepa L.). Brasília. 5. ed. Embrapa Hortaliças: Embrapa-CNPH.

Brasil, Ministério da Agricultura, Pecuária e Abastecimento. 2009. Regras para análise de sementes. Brasília: Mapa/ACS, 399 p.

Castro, C. and Oliveira, F.A. 2005. Nutrição e adubação do girassol. In: Leite, R.M.V.B.C., Brighenti, A.M., Castro, C. (Ed.). Girassol no Brasil. Londrina: Embrapa Soja, 318-373.

Freitas, L.B., Fernandes, D.M. and Maia, C.M. 2012. Interação silício e alumínio em plantas de arroz de terras altas cultivada sem solo alumínico. *R. Bras. Ci. Solo*, 36:507-515.

Furlani, A.M.C. 2004. Nutrição mineral. In: Kerbauy, G.B. Fisiologia vegetal. Guanabara Koogan, 40-75.

Gaetke, L.M. and Chow, C.K. 2003. Copper toxicity, oxidative stress, and antioxidant nutrients. *Toxicology*, 189:147-163.

Gupta, N., Gaurav, S.S., Kumar, A. 2013. Molecular basis of aluminum toxicity in plants: A Review. *Am J Plant Sci*., 4:21-37.

Lana, M.C., Steiner, F., Zoz, T., Fey, R. and Frandoloso, J.F. 2013. Tolerance of physic nut plants to aluminum activity in nutrient solution. *Biosci. J.,* 29(3):582-589.

Macedo, C.M.P., Lopes, J.C., Amaral, J.A.T. and Fonseca, A.F.A. 2008. Germinação e vigor de sementes de café submetidas ao estresse com alumínio. *Sci. Agric*., 9:235-239.

Machado, J.S., Steiner, F., Zoz, F., Honda, G.B. and Oliveira, B.L.N. 2015. Effects of aluminum on seed germination and initial growth of physic nut seedlings. *Revista de Agricultura Neotropical*, 2(1):24-31.

Malekzadeh, P., Mehr, R.S. and Hatamnia, A.A. 2015. Effects of aluminum toxicity on maize (Zea mays L.) seedlings. *Iranian Journal of Plant Physiology,* 5(2):1289-1296.

Milane, L.V., Rodrigues, L.A., Silva, J.B., Silva, T.R.B. and Alves, C.Z. 2014. Acidez e alumínio na germinação e desenvolvimento inicial de plântulas de milho. *J Agric Sci,* 3(1):188-198.

Nascimento, A.L., Escobar, A.C.N., Bradão. A.A., Batista, T.V. and Costa, C.A. 2010. Toxidade de alumínio Al+3 no processo germinativo de sementes de melão neve (Cucumis melo sp.). *Hortic Bras.,* 28(2):4392-497.

Rampim, L. and Lana, M.C. 2013. Mecanismo de tolerância interna das plantas ao alumínio. Colloquium Agrariae, 9(2):72-89.

Rossiello, R.O.R. and Jacob-Netto, J. 2006. Toxidez de alumínio em plantas: novos enfoques para um velho problema. In: Fernandes, M.S. (Ed.). Nutrição mineral de plantas. Viçosa: *SBCS*, 375-418.

Santos, C.A.C., Almeida, J., Santos, A.R., Vieira, E.L. and Peixoto, C.P. 2010. Rúcula em cultivo hidropônico submetida a diferentes concentrações de alumínio. *Biosci. J*., 26(6):905-912.

Scheffer-Basso, S.M. and Prior, B.C. 2015. Aluminum toxicity in roots of legume seedlings assessed by topological analysis. *Acta Sci., Agron.,* 37(1):61-68.

Taylor, H.M. and Arkin, G.F. 1994. Root zone modification fundamentals and alternatives. *Rev Bras Ciênc Solo.,* 18(3): p.491-497.

Trani, P.E., Breda Junior, J.M. and Factor, T.L. 2014. Calagem e adubação da cebola (Allium cepa L.). In: Aguiar, A.T.E., Gonçalves, C., Paterniani, M.E.A.Z., Tucci, M.L.S., Castro, C.E.F. Instruções agrícolas para as principais culturas econômicas, Boletim 200. 7 ed., IAC, 200, 35 p.

Yamashita, O.M. and Guimarães, S.C. 2011. Germinação de sementes de Conyza canadensis e C. bonariensis em função da presença de alumínio no substrato. Ciênc Rural, 41(4):599-601.

****