Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2020, Vol. 4 (1), 40-47
https://doi.org/10.29329/ijiaar.2020.238.5

Original article

Mineral Nutrition and Lipids in Chenopodiaceous

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Abstract

The environmental adaptation of the *Chenopodiaceae* (placed in *Amaranthaceae* s. l. in APG IV 2016) species is correlated with a physiological adaptation. Indeed, several species of this family are characterized by a C_4 photosynthetic pathway. The aim of this work is to evaluate the lipid structure of two plant species of the genus *Atriplex* (*halimus* and *canescens*) in order to elucidate the effect of mineral nutrition on lipid peroxidation. Thus, the effect of three concentrations of Na Cl (100 300 and 600 mMl^{-1}) was studied at the level of the two organs (roots and leaves) through the assay of Malondialdehyde (MDA) which represents a biomarker of lipid destruction. The results shows variability in the accumulation of MDA which indicate the variability of inter and intra specific responses. Nevertheless, the integrity of membrane lipids is little affected in both species and more in *Atriplex halimus L*.

Keywords: Mineral nutrition, lipids membrane, Malondialdehyde.

Received: 29 October 2019 * **Accepted:** 18 November 2019 * **DOI:** https://doi.org/10.29329/ijiaar.2020.238.5

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INTRODUCTION

Salinity is a major problem directly affecting the ecological balance and the development of agriculture in the Mediterranean basin, particularly North Africa. This phenomenon is considered as the most important abiotic factor limiting crops growth and productivity, degrading and polluting soils in arid and semi-arid (Boualem et al., 2019). Growth and development of plants are set harmoniously by external environmental selections and internal signals (Lin et al., 2007) However, the plants in the wild are exposed to multiple stressors (Anjuml et al., 2011) and their answers determine their ability to survive (Domrowski, 2003). The genus Atriplex encompassing about 300 species of angiosperms is well recognized ethnomedicinal genus which exists widely and utilized by aboriginal folks (Kamel et al., 2015; Kamel et al., 2017; Zohra et al., 2019). It belongs to family Chenopodiaceae which grows in Australia, Africa, Asia, and North America. These species are also known as saltbushes, because they are halophytes in nature and have adapted to grow in dry environment with salty soil. Due to their presence in extreme saline condition, a number of species of this group have been researched upon for their pharmacological activities, for example, secondary metabolites isolated from leaves of *Atriplex canescens* are used to cure infections of gastrointestinal in Mexico and its methanolic extract show anti-bacterial activity against E.coli and Salmonella typhimurium (Moreno et al., 2008). In Algeria, the leaves of *Atriplex halimus* are used in the treatment of presence of cystes in diverse organes (Miara et al., 2019). *Atriplex halimus* is suitable for phytostabilisation of (semi-) arid mine soils. So Compost and pig slurry favoured the phytostabilisation process and Soil quality increased after the addition of amendments and plant establishment (Clemente et al., 2012, Acosta et al., 2018). In our work we chose *halimus Atriplex* L. and *Atriplex canescens* Purch nutt. halophytic plants of economic and ecological interests (Romera et al., 2013 ; Walker et al., 2014). The current study has been aimed to evaluate the lipid structure of two plants species of the genus *Atriplex* (*halimus* and *canescens*) in order to elucidate the effect of mineral nutrition on lipid peroxidation through the assay of malondialdehyde (MDA).

Material and Methods

The seeds of *Atriplex. halimus* L. are native to the city of Oran. The seeds of *Atriplex canescens* (Pursh) Nutt. are taken from the atriplexaie of the El Bayadh region, located 370 km southeast of Oran and 520 km southwest of Algiers. The parameter of oxidative stress induced by salt, malondialdehyde (MDA) is determined using Hernández and Almansa (2002)

Experimental Protocol

The experiment is carried out at the Botany building of the University of Poitiers (French). The seeds of both species are washed in a 1% sodium hypochlorite solution for 5 minutes and then rinsed several times with distilled water. Seeding is done on potting soil in cells placed in the greenhouse. Seed watering is carried out with tap water and executed in the form of fine droplets in order to avoid the removal of seeds. Two-week-old seedlings are transplanted into pots 15 mm in height and 17 mm in diameter filled with a mix of potting soil and sand (Fontainebleau sand) in proportions of V / 2V. Watering is 60% of the substrate retention capacity (170 ml of nutrient solution professional Peters solution) three times a week until the application of salt stress (Na Cl) four months after sowing. The photoperiod is 16 hours and the relative humidity is 60%. The temperature fluctuated between 22 and 24 ° C. Three saline treatments were retained, 100, 300 and 600 mM/l of nutrient solution. Stress is applied gradually by increasing the saline concentration by 50 mM-1 per day. Once the salt concentration is reached, the plants are watered for 30 days at a rate of three times per week in the saline solution. At the end of the stress, the plants are harvested. The roots are separated from the aerial parts and then all are washed under running water, packed in freezer bags and stored at -20 ° C.

Dosage of malondialdehyde

Lipid peroxidation is estimated by determination of malondialdehyde (MDA) levels (Hernandez and Almansa, 2002) at the roots and leaves. 50 mg of dry matter samples of different saline treatments are ground and then homogenized in 2 ml of trichloroacetic acid (TCA) at 1%. The homogenate is centrifuged at 15000 g for 10 minutes at 4 ° C. 0.5 ml of the supernatant are mixed with 1.5 ml of thiobarbituric acid (TBA) prepared in 20% TCA and incubated at 90 °C. for 20 minutes. After stopping the reaction in ice, the samples are centrifuged at 10.000 g for 5 min. The absorbance of the supernatant is read at 532 nm. After subtracting the absorbance nonspecific at 600 nm, the concentration of MDA is determined using the extinction coefficient 155 / Mm / cm. All tests were done in triplicate.

Statistical analysis

The results are analyzed by an analysis of variance (ANOVA) to evaluate the significance of the effect of different salt concentrations on the level of MDA and consequently on the levels of degradation of membrane lipids. The averages are then ranked by the Tukey Test (HSD) using the XLSTATS 2019 (version 3.2.62756). Constraints: a1 = 0, Confidence interval (%): 95, Tolerance: 0.0001.

Results

Effect of salt stress on Malondialdehyde (MDA)

The results show a variability of accumulations of MDA, the final product of lipid peroxidation, considered as an indicator of oxidative stress resulting from several abiotic stresses (Hernandez et al., 2000). This variability is observed in both control and treated plants, which highlights intra-specific variability. The accumulation of MDA at the root level (Figure.1) of *Atriplex halimus* L. (25.90 µmol.g^{-1} DW) at low salt concentration (100 mM.l-1), less than that shown by the roots (Figure. 2) of *Atriplex canescens* (Pursh) Nutt. (32.83 µmol.g^{-1} DW) at the moderate concentration (300 mM.l^{-1}), suggests that the species *Atriplex halimus* L. is sensitive to salt at low concentrations whereas *Atriplex canescens* (Pursh) Nutt. only at higher concentrations.

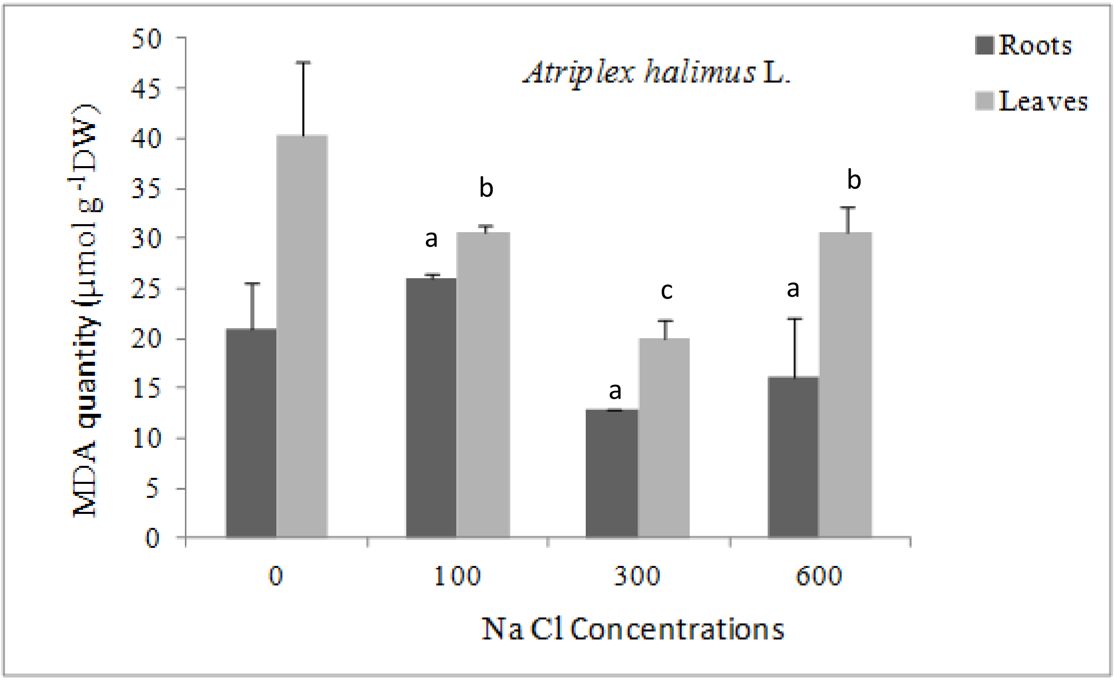

Figure 1. MDA content (µmol/g D W) of roots and leaves of *Atriplex halimus* L. under salt stress.

a-b-c-: values in the same column with different letters are significantly different ($P<0.05$)

In terms of content and not regarding stress, *Atriplex canescens* (Pursh) Nutt. has slightly larger values, indicating more pronounced cell membrane damage in this species. this highlights that the two species differ in their ability to compartmentalize the salt in the cells of their roots.

The results obtained also show a decrease in the level of MDA in the leaves of the two species, whatever the saline concentration applied, this reduction is a function of the concentration of NaCl in the leaves of *Atriplex canescens* (Pursh) Nutt. in the leaves of *Atriplex halimus* L., it is more important at moderate concentration than at the other two treatments (low and high), the quantity of which remains almost unchanged (30.70 and 30.71 µmol/g DW).

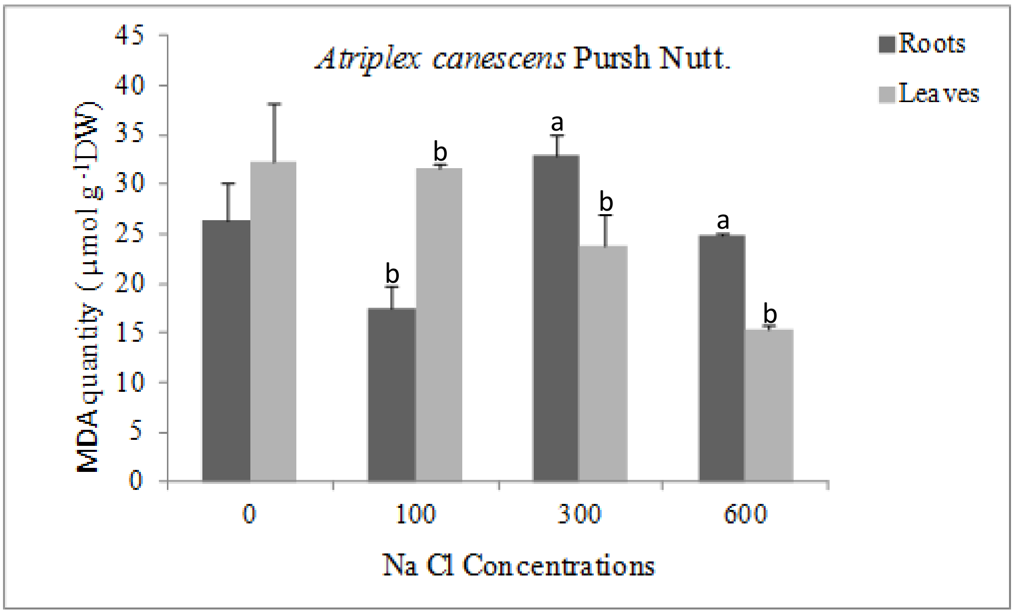

Figure 2. MDA content (µmol/g D W) of roots and leaves of *Atriplex canescens* Pursh Nutt. under salt stress.

a-b-c-: values in the same column with different letters are significantly different ($P<0.05$)

Discussion

The difference in the ability to maintain root water balance is already proposed by KSOURI et al. (2007). A similar decrease is observed in the Cakile maritima halophyte, where the MDA content decreases with salinity in the Tabarka variety (KSOURI et al., 2007). The same observation is observed in the transgenic lines (introduced *Atriplex hortensis* AhCMO gene) of cotton (*Gossypium hirsutum* L.) where the MDA content decreases at 150 mM.l^{-1} NaCl (Zhang et al., 2009). On the other hand, these results are in contradiction with those obtained by several authors (Moradi et Ismail, 2007, Liang et al., 2008; Toumi et al 2014) in the rapeseed, *Cakile maritima*, the rice, the wheat and the colza (*Brassica napus* L.) among which, the content in MDA increases with the degree of salinity. Daud et al. (2015) find that the level of MDA increases in cotton (*Gossypium hirsutum* L.) stressed with cadmium and in *Atriplex halimus* L. stressed with Arsenic (Tapia et al 2013). The level of invariable MDA appears to be a characteristic of salinity-tolerant plants and the degree of cellular oxidative damage in plants exposed to abiotic stress is a function of the plants' ability to protect against oxidative agents (Shalata et al., 2001; Ashraf et Harris, 2004). According to Hichem et al. (2009), the impact of salt stress is greater in senescent leaves than mature or young leaves of two varieties (Arper and Aristo) of maize; they relate the salt tolerance of Arper leaves to the ability of the latter to accumulate polyphenols, in particular anthocyanins which, according to these authors, contribute effectively to the restriction of oxidative damage caused by the formation of peroxide hydrogen molecules. In addition, the low vigor and germination capacity of wild Brassicaceae species (Brassica repanda, Moricandia arvensis, Rorripa nasturtium-aquaticum and Sinapis alba) is related to a change in lipid peroxidation and membrane integrity (Mira et al., 2011). These authors suggest that lipid peroxidation is not the cause of the deterioration of the seeds of these species. As a result, accumulation of malondialdehyde is not associated with low seed viability. Lipid peroxidation of both species are very little or not affected by the salt for all concentrations applied reflecting a better protection of cell membranes against oxidative damaging effects of salt. However, in terms of peroxidase activity, variability of responses is observed. This variability is a function of the salt concentration, the organ and species (Mahi et al., 2015). In response to salt stress, peroxidase activity POD of *Atriplex canescens* (Pursh) Nutt. shows no noticeable change, suggesting that this activity is not or very little involved in the detoxification of reactive oxygen species (ROS) (Mahi et al., 2015). In general, halophytes displayed higher antioxidant capacity (AC) and total phenolic content (TPC)) than non-halophytes. High correlation indicated a major contribution of TPC in AC of these plants according to Qasim et al., (2017). HPLC analyses showed that the hydrolysed extracts contained chlorogenic acid, gallic acid, catechin, and quercetin as abundant phenolic metabolites which may be responsible for higher AC. These plants were also found to contain suitable amounts of proteins (8.5–17%), carbohydrates (2.6–11.4%), fibre (31.6–41.2%), and minerals (2.1–9.7%) showing their nutritional potential that has already been exploited by rural communities. The present study highlights the potential of medicinal halophytes as a source of natural antioxidants, valuable phytochemicals, and essential nutrients for pharmaceutical, nutraceutical, and chemical industries (Qasim et al., 2017).

Conclusions

The structure of the lipids membrane is very little affected by salt in both species. *Atriplex canescens* (Pursh) Nutt. has slightly larger values indicating more pronounced cell membrane damage in this species. The present study highlights the potential of these halophytes as a source of natural antioxidants, valuable phytochemicals, and essential nutrients for pharmaceutical, nutraceutical, and chemical industries.

Acknowledgments

The author would like to gratefully acknowledge the support of Mrs. Fabienne Dedaldechamp, and Mr Rémi Lemoine of the Laboratory of Botanical Building of Poitiers.

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