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EFFECT OF SOIL SALINITY ON TOMATO GROWTH (*LYCOPERSICUM ESCULENTUM* MILL.) CULTIVATED IN INTERCROP WITH *ATRIPLEX HALIMUS* L.

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Abstract

Salinity is an ecological constraint for the soil in the world; this phenomenon is considered as the most important abiotic factor which limits the growth and the productivity of plants. The present work was to follow in a first step the morpho-physiological and chemical behavior of the tomato cultivated in intercrop with *Atriplex halimus* L. and subjected to salt stress and in a second step we evaluate the effect of the *Atriplex halimus* L. on the evolution of soil salinity.

A decrease in leaf area, in potassium content and in total chlorophyll was recorded in tomato plants subjected to saline stress; however sodium levels have increases in the same plants.

The presence of *Atriplex halimus* L. leads to a decrease in soil salinity and has a beneficial effect on tomato plants growth.

Key words: salinity, *Atriplex halimus* L., tomato, intercrops.

Introduction

Salinity is a major constraint to productivity and agricultural development, by reducing the growth and development of plants (Rasool and *et al*., 2013). It causes a water deficit in plants in the form of physiological dryness (Mahajan and Tuteja, 2005) by lowering the relative water content of the leaves (Kaya and *et al*., 2003; Katerji and *et al*., 2003; Soualmi and *et al*., 2017).

According to Wang and Nil, (2000) the immediate response is to reduce the rate of expansion of the leaf surface. All major processes such as: photosynthesis, protein synthesis, energy metabolism are affected (Parida and Dasa, 2005).

Salinity is apt to disturb the mineral nutrition of plants, by limiting the removal of certain essential elements such as potassium and calcium (Haleem and Mohammed, 2007; Maksimovic and *et al*., 2010; Perveen and *et al*., 2012).

It is possible to limit the extent taken by the salinization of land and water by exploring saline ecosystems and identifying halophile species with economic and / or ecological potential in order to use these naturally salt-tolerant species for rehabilitation and enhancement of saline soils (Belkhodja and Bidai, 2004).

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A trial of an intercropping between a halophile *Atriplex halimus* L. and the tomato (*Lycopersicum esculentum* Mill) on naturally salty soils, was carried out in pots, in order to study the incidence of *Atriplex halimus* L. on tomato growth and on the evolution of the soil salinity

Material and Methods

Plant material and growth conditions

Two plant species were tested, the tomato (*Lycopersicum esculentum* Mill) from the Solanaceae family and the *Atriplex halimus* L. from the chenopodiaceous family.

The substrate used corresponds to five types of soil (unsalted soil; little salty; salty; very salty and extremely salty) with different levels of salinity (Table 1). These five types of soil selected are taken from the experimental site of the National Institute of Agronomic Research (INRA) of Relizane, Algeria.

The experiment was conducted under shelters, the young plants of *Atriplex halimus* L. and of tomato are transplanted in pots filled with the five types of soil studied beforehand. Each soil type has 10 pots (05 pots for the tomato intercropped with *Atriplex halimus* L. and 05 pots for the tomato grown alone).

Table 1: Salinity levels of the different soils types used.

Soil type	unsalted	little salty	salty	very salty	extreme salty
Electrical conductivity (dsm/m)	0,15	4,41	8,86	15,52	22

Hydromineral nutrition of plants was ensured by watering done three times a week with distilled water substituted one faith out of three with a nutrient solution of the WUXAL Macromix type.

Measurements and analyzes made on the tomato

- Measurement of leaf area
- Extraction and determination of total chlorophyll
- Analysis of the plant's chemical parameters: determination of sodium and potassium.

Analyzes made on the soil

To assess the effect of the presence of *Atriplex halimus* L. on the soil salinity level, parameters were measured on all soil samples before the installation of the culture and after the digging up of the plants which are:

- The electrical conductivity of the aqueous extract
- Soluble salts (sodium, potassium)

Statistical analyzes

All the data obtained were the subject of a statistical study based on a two-factor analysis of variance (ANOVA), plus a comparison between the means according to the Dunnett test at $p < 0.05$.

Results

Effect on tomato

- Leaf area : From the results obtained in fig. 1, we observe a better development of the leaf surface of the tomato plants cultivated as an interlayer of the *Atriplex halimus* L. compared to those cultivated alone.

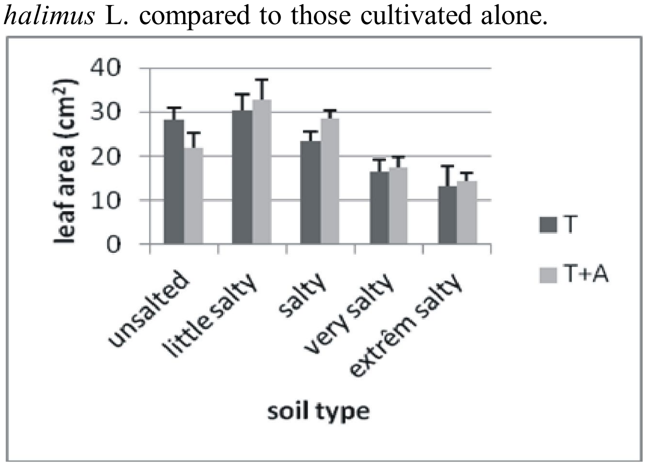

Fig. 1: Effect of soil salinity on tomato leaf area cultivated in intercrop with *Atriplex halimus* L.

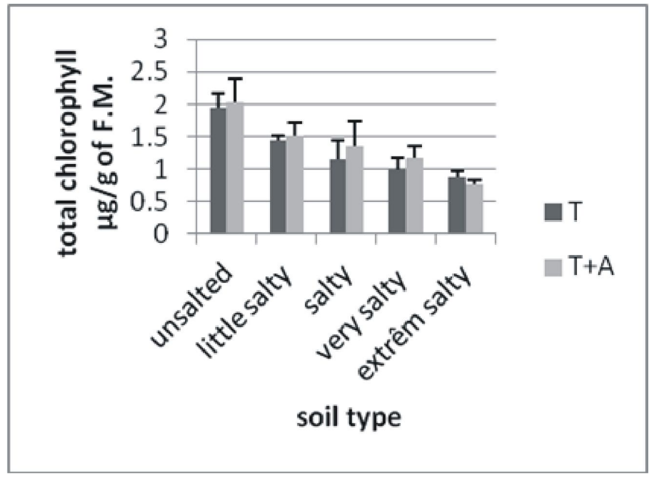

Fig. 2: Effect of soil salinity on tomato total chlorophyll content, cultivated in intercrop with *Atriplex halimus* L.

- Total chlorophyll : The chlorophyll content of tomato plants decreases significantly with increasing soil salinity. For all levels of salinity except for extremely salty soil, this content is higher in tomato plants associated with *Atriplex halimus* L. than those planted alone.

- Sodium : Under the effect of salt stress, the average Na^+ content increases significantly with the intensity of salt stress for the two batches (T, T + A). With the exception of extremely salty soil, the presence of *Atriplex halimus* L. causes a significant decrease in the level of Na^+ in tomato plants in the presence of different salt concentrations.

- Potassium : The results mentioned in fig. 4, show that the potassium contents of the tomato decrease significantly with the increase in the salinity of the soil. The two batches (T, T + A) responded in the same way to the presence of the salts. However, tomato plants intercropped with the *Atriplex halimus* L. tend to accumulate higher levels of K^+ compared to those grown alone.

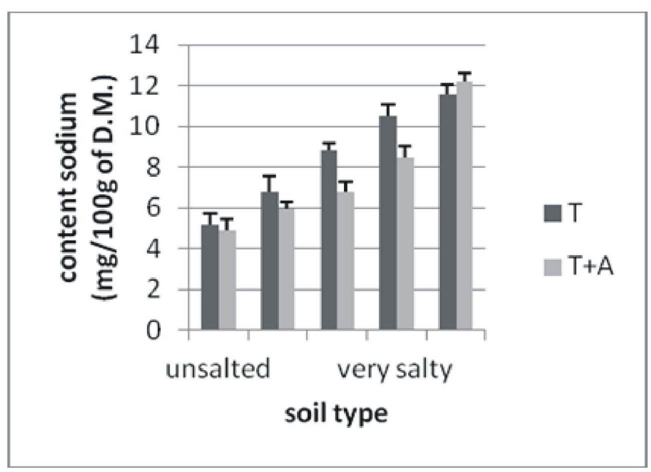

Fig. 3: Effect of soil salinity on tomato leaf sodium content, cultivated in intercrop with *Atriplex halimus* L.

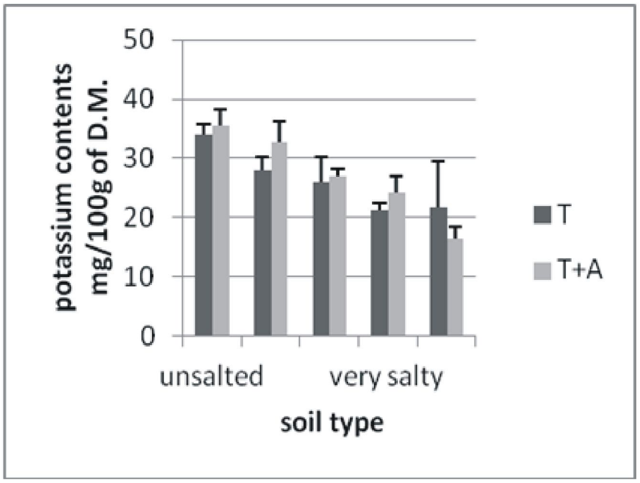

Fig. 4: Effect of soil salinity on tomato leaf potassium content, cultivated in intercrop with *Atriplex halimus* L.

Effect on the soil

The fig. 5 shows that the electrical conductivity of the soil solution has notable variations; it decreases depending on the type of culture. This decrease is more important in soil samples cultivated by *Atriplex halimus* L. associated with tomato plants. Whose the most remarkable variations are recorded for extremely salty soil (T + A) with a reduction in electrical conductivity of 41.56% compared to non-cultivated soil and 32.26% compared to soil cultivated only by tomatoes (T).

For the same type of soil, sodium accumulates less in the soil solution cultivated by *Atriplex halimus* L. compared to soil cultivated only by tomatoes and uncultivated soil. (Fig. 6).

As for potassium, fig. 7, Shows us that the presence of tomato and *Atriplex halimus* L. reduces the potassium concentration in the solution of unsalted and slightly salty soil compared to the same soil before cultivation.

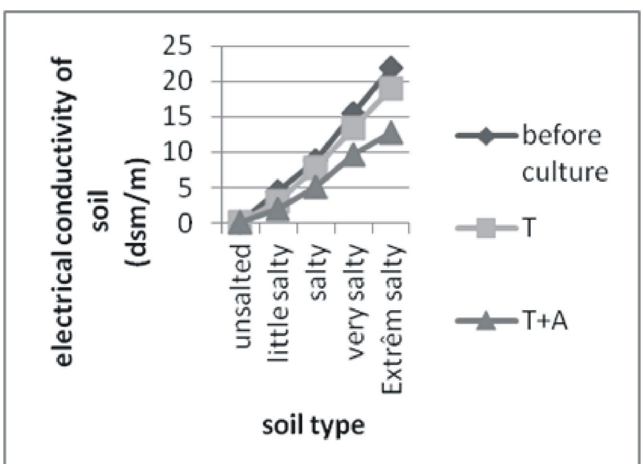

Fig. 5: Evolution of the electrical conductivity of the soil solution (CEs) of the aqueous extract according to the type of culture installed.

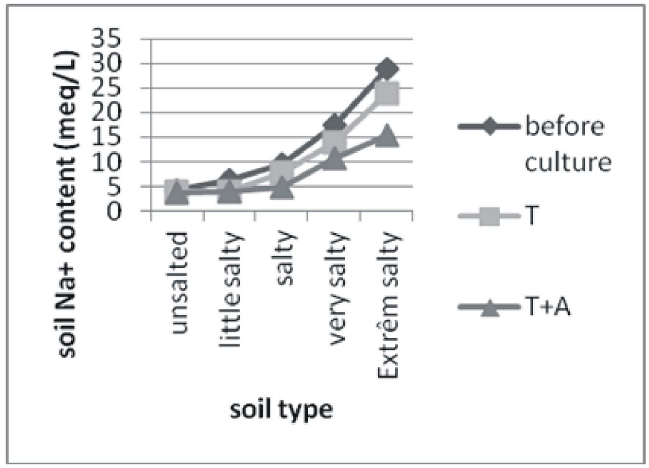

Fig. 6: Evolution of the sodium concentration of the soil solution (meq / l) of the aqueous extract according to the type of culture installed.

For the other types of soil the k^+ accumulates more in the solution of the soil cultivated only by the tomato compared to that not cultivated with a maximum difference of 73.10% recorded on the extremely salty soil.

Discussion

High concentrations of salinity have a depressive effect on growth, a decrease in leaf area has been observed in tomatoes exposed to high concentrations of salts. According to Kahlaoui and *et al*., (2009) this decrease is due to a general reduction in plants.

The reduction in growth may also be linked to disturbances in the levels of growth regulators (abscisic acid and cytokinins) induced by the salt (Kuiper and *et al*., 1998) sometimes to a reduction in photosynthetic capacity following a reduction in the stomatal conductance of CO_2 under the salt constraint (Santiago and Termaat, 1986). However, the tomato leaf area cultivated as an

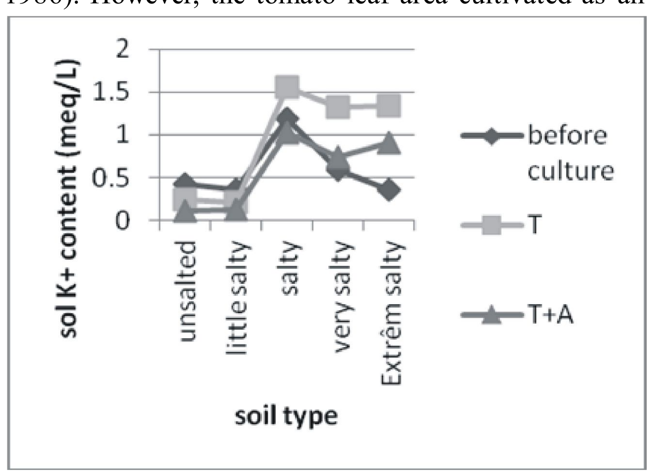

Fig. 7: Evolution of the potassium concentration of the soil solution (meq / l) of the aqueous extract according to the type of culture installed.

interlayer of *Atriplex halimus* L., is greater than that cultivated alone, this probably results from the ability of *Atriplex halimus* L. to pump Na^+ and consequently decrease the salinity of the soil.

Regarding the total chlorophyll content, it decreases significantly with increasing salinity. These results are reported by Baker and Rosenqvist, (2004) on the tomato, by Lycoskoufis and *et al*., (2005), by Niu and *et al*., (2010) on chilli pepper and by Achour, (2016) on okra. These levels are generally higher in the presence of *Atriplex halimus* L. than in its absence.

The regulation of mineral nutrition is qualified to be an important characteristic of plant tolerance against a variety of stresses, including salt stress (Ashraf and *et al*., 2008; Akram and *et al*., 2009). In our experience, plants have shown variation in sodium accumulation.

Indeed, Na^+ accumulates more in the leaves of tomatoes exposed to high concentrations of salts. These results are reported by Arbaoui, (2016). The accumulation of Na^+ is also less in the leaves of the tomato associated with *Atriplex halimus* L. compared to the tomato grown alone. Apparently this decrease results from the regression of the concentrations of this element in the soil solution (Fig. 6) which may be due to its translocation by the *Atriplex halimus* L.

The accumulation of potassium slows remarkably under the effect of the salts. The same results are reported by Habib and *et al*., (2012) and by Achour, (2016) on okra. However, this ion accumulates more in tomato plants intercropped with *Atriplex halimus* L. compared to those grown alone. This increase is probably due to the decrease in Na^+ concentrations in the soil solution in the batch (T + A) (Fig. 6), it is known that Na^+ in the plant limits the absorption of essential cations such as K^+ and Ca^{+2} (Arbaoui, 2016).

Salinization is the process by which soluble salts accumulate in the soil (USDA, 1998). It can be evaluated by measuring the electrical conductivity of the soil solution CEs. In species of the genus Atriplex, there is a preferential translocation of the Na^+ ions towards the aerial parts (Riemann, 1992). The *Atriplex halimus* L. absorbed significant quantities of sodium accumulated in the soil and it contributed to decrease the EC of the soil solution.

The low potassium concentrations in the solution of unsalted and low-salted cultivated soil are due to the fact that potassium is used by plants in their metabolism. While its accumulation with high values in the very salty and extremely salty soil solution is explained by its non-use by plants because of the presence of high concentration of Na^+ (Fig. 6) which limits the use of K^+ by plants. Work on other cultures has presented similar results (Glass and *et al*., 1981; Aylaji and *et al*., 2001).

Conclusion

Studying the effect of salinity on tomato growth has allowed us to see the depressive effect that salinity plays on tomato plants. The presence of *Atriplex halimus* L. as an interlayer of tomato allowed us to assess the beneficial effect of this halophile in improving the morpho-physiological and chemical behavior of the tomato.

This improvement is represented by an increase in the leaf area and the total chlorophyll content. Better absorption of potassium has been noted in tomato plants due to the ability of *Atriplex halimus* L. to pump sodium.

At ground level, the presence of *Atriplex halimus* L. causes a decrease in soil salinity.

References

Achour, A. (2016). Physiological and Biochemical Characterizations of Okra (*Abelmoschus esculentus* L.) under Saline Stress. Doctoral thesis in Biological Sciences, Oran University 1 Ahmed Ben Bella.

Akram, M.S., M. Ashraf and N.A. Akram (2009). Effectivenes of potassium sulfate in mitigating salt-induced adverse effects on different physio-biochemical attributes in sunflower (*Helianthus annuus* L.). *Flora.*, **204:** 471-483.

Arbaoui, M. (2016). Effect of salt stress on tomato (*Lycopersicum esculentum* Mill) seedlings grown on sandy substrates amended with bentonite. Doctoral thesis in Biological Sciences, Oran University 1 Ahmed Ben Bella.

Ashraf, M. Athar, H.R. Harris, P. J.C. and T.R. Kwon (2008). Some prospective strategies for improving crop salt tolerance. *Adv. Agron.*, **97:** 45-110.

Aylaji, M. El.Kbir, L. Kabil, M. and A. Ouaaka (2001). Impact of water salinity on soil quality and sugar beet *Beta-vulgaris* L. *J. French industrial ecology.*, **24:** 23-27.

Baker, N.R. and E. Rosenqvist (2004). Applications of chlorophyll fluorescence can improve crop production strategies: an examination of future possibilities. *J. Exp. Bot.*, **55:** 1607-1621.

Belkhodja, M. and Y. Bidai (2004). Response of *Atriplex halimus* L. seeds to salinity at the germination stage. *Drought:4.*, **15:** 331-335.

Glass, A.D.M. Siddiqi, M.Y. and K.J. Giles (1981). Correlations between potassium uptake and hydrogen efflux in barley varieties. *plant physiol.*, **68:** 457-459.

Habib, N. Ashraf M. Ali, Q. and R. Perveen (2012). Response of salt stressed okra (*Abelmoschus esculentus* Moench) plants to foliar-applied glycine betaine and glycine betaine containing sugarbeet extract. *South African Journal of Botany.*, **83:** 151-158.

Haleem, A. and M.A. Mohammed (2007). Physiological aspects of mungbean plant (*Vigna radiata* L. wilczek) in response to salt stress and gibberellic acid treatment. *Res. J. Agric. Biol. Sci.*, **3:** 200-213.

Kahlaoui, B. Hachicha, M., S. Rejeb, M.N. Rejeb and B. Hanchi (2009). Improvement of the salt tolerance of three varieties of tomato irrigated by drip on the surface and buried. *INRGREF Annals.*, **14:** 21-28.

Katerji, N. Van Hoorn, J.W. Hamdy, A. and M. Mastrorilli (2003). Salinity effect on crop development and yield analysis of salt tolerance according to several classification methods. *Agric. Water Management.*, **62:** 37-66.

Kaya, C. Higgs, D. Kirnak, H. and I. Taş (2003). Amelioratrive effect of calcium nitrate on cucumber and melon plants drip irrigated with saline water. *Journal of Plant Nutrition.*, **26:** 665-1681.

Kuiper, F.J., D.M. Chen and F.L. De Filippis (1998). Respiratory, photosynthetic andultra structural changes accompanying salt adaptation in culture of *Eucalyptus microcorys*, *J. Plant Physiol.*, **152:** 564-573.

Lycoskoufis, I.H., D. Savvas and G. Mavrogianopoulos (2005). Growth, gas exchange and nutrient status in pepper (*Capsicum annuum* L.) grown in recirculating nutrient solution as affected by salinity imposed to half of the root system. *Scientia Horticulturae.*, **106:** 147-161.

Mahajan, S. and N. Tuteja (2005). Cold salinity and drought stresses. *An overview Archives of Biochemistry and Biophysics.*, **444(2):** 139-158.

Maksimović, I. Putnik-Delić, M. Gani I., Marić, J. and Ž. Ilin (2010). Growth, ion composition and stomatal conductance of peas exposed to salinity. *Open Life Sci.*, **5(5):** 682-691.

Niu, G. Rodriguez, D.S. and T. Starman (2010). Response of bedding plants to saline water irrigation. *Hort Science.*, **45(4):** 628-636.

Paridas, A.K. and A.B. Dasa (2005). Sallt tolerance and salinity effects in plants: *a review ecotoxycology and environment safety.,* **60:** 324-349.

Perveen, S. Shahbaz, M. and M. Ashraf (2012). Changes in mineral composition, uptake and use efficiency of salt stressed wheat (*Triticum aestivum* L.) plants raised from seed treated with triacontanol. *Pak. J. Bot.*, **44:** 27-35.

Rasool, S. Hameed, A. Azooz, M.M. Rehman, M. Siddiqi, T.O. and P. Ahmad (2013). Salt Stress: Causes, Types and responses of plants In: Ahmad, P. Azooz, M.M. Prasad, M.N.V., (Eds.), Ecophysiology and responses of plants under salt stress. Springer New York Heidelberg Dordrecht London, 1-24.

Riemann, C. (1992). Sodium exclusion by Chenopodium species. *J. Exp. Bot.*, **43:** 501-512.

Santiago, R. and A. Termaat (1986). Whole plant responses to salinity, Aust. *J. Plant Physiol.*, **13:** 143-160.

Soualmi, N. Belkhodja, M. and A. Adda (2017). Effect of salt stress on some physiological parameters in *Atriplex halimus* L. *J. Fundam. Appl. Sci.*, **9(1):** 206-216.

USDA (1998). Natural Resources Conservation Service Soil Quality Resource Concerns: Salinization. 2.

Wang, Y. and N. Nil (2000). Changes in chlorophyll, ribulosebiphosphate carboxylase– oxygenase, glycine betaine content, photosynthesis and transpiration in *Amaranthus tricolor* leaves during salt stress. *J. Hortic. Sci. Biotechnol.*, **75:** 623-627.