



## Effects of Different Salt Applications on Ion and Physiological Analysis in Lettuce

Turgay Kabay<sup>1,a,\*</sup>

<sup>1</sup>Ercis Vocational School Van Yüzüncü Yıl University, 65090 Van, Türkiye

\*Corresponding author

### ARTICLE INFO

Research Article

Received : 25/04/2022

Accepted : 29/07/2022

Keywords:

Lettuce

Nutrient element

Plant development

Salt stress

Leaf membrane damage

### ABSTRACT

The increase in salinization in agricultural lands adversely affects crop production. In particular, yield and quality losses occur in many vegetables such as lettuce, which are grown and consumed in every season. Realizing these losses in crop production, more careful fertilization and agricultural practices should be done. Yedikule lettuce seeds were used in the study to draw attention to these negative aspects. The study, which was carried out for two years, was designed with 0, 50, 100 and 150 mmol doses of salt according to a randomized parcel design with three replications and four pots in each replicate. Each 2-liter pot was filled with a 2:1 ratio of peat: perlite mixture and the study was carried out with 2 lettuces in each pot. As a result of the study, when the plant weight data of the first year and the second year are examined, it is seen that the weight loss of lettuce plants and damage to the plants increase when the salt doses increase. It was observed that the highest plant weight loss occurred at 150 mmol salt dose. Membrane damage index in lettuce leaves was observed to increase as the salt dose increased. It was observed that the leaf water rate decreased with increasing salt doses. Membrane damage index and leaf water content of lettuce plants were more negatively affected at 150 mmol of salt in both years. Potassium, calcium and magnesium contents in lettuce leaves were statistically decreased due to increasing salt doses in both years, while sodium content increased with increasing salt doses and the highest sodium content was observed at 150 mmol dose in both years. As seen in these results, increasing salt doses reduce the nutrient content and plant weight in lettuce plants and cause physiological damage to the plant, resulting in yield and quality loss.

[turgaykabay@gmail.com](mailto:turgaykabay@gmail.com)

<https://orcid.org/0000-0002-3239-0037>



This work is licensed under Creative Commons Attribution 4.0 International License

## Introduction

As a result of wrong agricultural practices, the problem of salinization in agricultural lands increases every year. Increasing salinization causes economic losses to the producers as it reduces the yield and quality in herbal production (Korkmaz et al., 2020). The importance of taking measures to protect the environment and production environments in organic production is kept on the agenda by constantly emphasizing salinity problems through scientific studies (Ekbic et al., 2017; Dinler et al., 2021)

In dune spinach study doses administered salt doses 50, 100, and 200 mM NaCl, an increased level of salinity (200 mM) caused a decrease in chlorophyll content, as well as nitrogen, phosphorus, and sodium, increased (Sogoni et al., 2021). In the study on salt (100 mM NaCl) resistance of AGR-703, Vista-306, Köksal F1 and Yula F1 eggplant varieties produced in Türkiye, green part fresh and dry weight, root fresh and dry weight, root-stem length, leaf area, green in terms of the amount of Na, K, Ca and Cl ions and chlorophyll, lipid peroxidation level and antioxidative

enzyme activities, Köksal F1 variety is stated to have a very good resistance to salt stress (Kıran et al., 2015). It is stated that the salt stress applied in pepper reduce macro element content, stem and root fresh weight and dry weight (Tuna and Eroğlu 2017). In a study conducted to determination of salt tolerant genotypes in the okra plant, it was emphasized that green component K and Ca content decreased and Na content increased (Kuşvuran, 2011). In the study, which determined the salt tolerance of local melons grown in Türkiye, it is stated that the development of new varieties with high tolerance to salty conditions of Koçhisar melon, Van and Mardin melon grown around Tuz Gölü is important for the evaluation (Kuşvuran et al., 2012). In the study of application of microorganisms that promote plant growth to improve the salt tolerance of lettuce and tomato seedlings irrigated with different salinity levels, it is stated that (0, 25 and 50 mM NaCl) salt applications during seedling growth negatively affect many morpho-physiological parameters of lettuce and

tomato seedlings (Miceli et al., 2021). In the study results to seven onion cultivars from Türkiye for biochemical and gene expression responses to drought and salt stresses under greenhouse conditions, revealed that the cultivars Perama, İnci, and Seyhan were tolerant, whereas the cultivars Elit and Hazar were grouped as sensitive to salt (Chaudhry et al., 2021). In a study to determine the germination properties of bean and cowpea seeds of salt solutions (0-50-100-150-200 mM) at different doses, increased salt doses decreased germination rate, radicle fresh and dry weight (gr), (Özkorkmaz and Yılmaz, 2017). In a study to determine the adverse effects of salt (EC = control, 6, 8 and 10 dS<sup>m<sup>-1</sup></sup>) on spinach leaf physiology, the leaf water potentials, the total amount of chlorophyll and the stomatal conductance decreased in the leaves while the membrane damage rate increase in leaf cells (Deveci and Tuğrul, 2017).

As a result of the application of salty water to the cucumber, it is indicated that the Na and Cl ratios increase in the leaves while the Na and Cl ratios decrease in the leaves of salt tolerant rootstocks (Usanmaz and Abak, 2018). As a result of the application of CaCl<sub>2</sub> and NaCl salt to tomato (*Solanum lycopersicum* L.), it was indicated that N and P contents were increased in the leaves and Mg, S, Fe, Mn contents were decreased in salt conditions (Korkmaz et al., 2017). In a study of the effects of Arbuscular Mycorrhizal Fungi on plant growth in pumpkin seed genotypes during seedling in saline soil conditions, it is stated that Mycorrhizal Fungi applications on plants affected positively (Abdulhadi et al., 2017). In a study to evaluate the effects of irrigation using saline water on the chile pepper, at end of the study they have reach the result that all pepper genotypes have been shown to reduce, photosynthesis, stomatal conductance (Baath et al., 2017). It has been reported that the effect of the five salinity levels on the sweet basil plant and yield of basil plant was significantly reduced by the increased salt contents (Çalışkan et al., 2017). In study of salt and heat stress applied to Arabidopsis plants, the amount of Na increased and the amount of K decreased in plant leaves (Suzuki et al., 2016). It has been shown that bean genotypes applied drought and lettuce genotypes applied salt stress; K and Ca contents are lower in drought and salt sensitive varieties whereas drought and salt tolerant genotypes are close to control plants (Kabay and Şensoy, 2016; Kabay and Şensoy, 2017; Kabay et al., 2017; Kabay, 2018).

In this study, it was aimed to determine the changes in weight loss, leaf water ratio, membrane damage index, K, Ca, Mg and Na amounts in lettuce plants in both fields by applying 50, 100 and 150 mmol salt doses to Yedikule lettuce.

## Material and Methods

The study we conducted to determine the effects of salt stress on lettuce plant was designed to be 3 repetitions and 4 pots each repeat, according to randomized experimental design, between 25 April 2016 and 24 April 2017. Yedikule lettuce seeds we used, were planted 4 seeds in 2 liters pots containing 2: 1 mixture of peat + perlite and 2 plants remained in each pot. From seed planting, pots contained salt and control plants were irrigated with Hoagland nutrient solution. When lettuce plants had 5

leaves, 50, 100 and 150 Mmol salt applications were made on each pot. The salt applied plants and control plants were continued to be irrigated with the Hoagland nutrient solution until the study was finished the experiment was completed 15 days after the salt application. At the end of the study, the analysis of plant weight, membrane damage index, leaf proportional water content, K, Ca, Mg and Na contents were investigated.

### *Lettuce Weight Harvested*

The harvested lettuce was weighed on precision scales and averaged.

### *Leaf Proportional Water Content*

At the end of the study, lettuce leaves were weighed, the weighed leaves were kept in distilled water for four hours and then harvested again. Finally, it was calculated by weighing the lettuce leaves after being kept in an oven at 65°C and 48 hours.

### *Leaf Membrane Damage*

Lettuce leaf membrane damage was calculated by measuring the electrolyte leaving the cell of the lettuce leaves. (Jebera et al., 2005; Kuşvuran, 2010; Bağcı, 2010).

### *Mineral Element Analysis*

When the study is finished, the leaf from plants were dried in an oven at 65 °C until reaching to a constant weight. Then, the dried samples Mg, K, Ca and Na was determined in an atomic absorption device (Jebera et al., 2005; Kuşvuran, 2010; Bağcı, 2010).

### *Statistical Analysis of The Study*

Analysis of Variances based on general linear models (Yeşilova and Denizhan, 2016). Carried out by SAS 9.4.1 statistical program was used. Duncan multiple Comparison tests was used to measure the statistical differences between genotypes.

## Results and Discussion

Salty lands reduce the market value of agricultural products. This situation puts the producers in financial problems. The study carried out between April and May years of 2016 and 2017. The effects of 50, 100, 150 Mmol salt applications of Yedikule lettuce which has a high consumption rate in our country, were investigated. In our study, according to first year data, the fresh weight of the control plant was 286.51 g while 54.86 g was found in 150 Mmol of salt application. When the second-year data were taken into account, the weight of the control plant was 395.24 g, while the lowest weight (49.68 g) was found in 150 Mmol salt application. (Table 1, 2). When membrane damage index of lettuce leaves was examined, it was 0.98% in the first year in control plants while it was 1.64% in the second year of study. The highest value of the membrane damage index was found in 150 Mmol of salt application and leaf membrane damage found 68.54% in the first year while 75.15% in the second year. (Table 1, 2). While the leaf water proportional content of control plants was 83.77% in the first year of lettuce plant, 86.63% was found in the second year. When the first-year data of leaf proportional water content is taken into account,

statistically, minimum leaf proportional water content is seen in 100 and 150 Mmol applications of salt. When the second-year data were taken into account, leaf water proportional content was found to be minimum statistically in 150 Mmol salt application with 39.27% (Table 1, 2).

It was seen that the salt application decreased the K, Ca and Mg contents in Yedikule lettuce plant every two years. The K ratio of control plants was 6.7% in the first year, whereas it was 6.85% in the second year. However, it was seen that the amount of K decreased data of every two years. In the first year, the K ratio in 100 and 150 Mmol application of salt was statistically the same group and they were 5.82% and 5.77% respectively. In the second year, the amount of K was lowest in 150 Mmol salt application (Table 3, 4). When the Ca and Mg ratios were examined, the highest rate was observed in the control group every two years (Table 3, 4). Ca: 1.82% and Mg: 0.37% in 150 Mmol salt application in the first year whereas Ca: 1.75% and Mg: 0.25% in 150 Mmol application in the second year. When we looked at Na content, Na content of the control group plants in the first year was lowest with 0.09%. In the first year 150 Mmol application of salt, the amount of Na increased by 1.90% and it was seen that similar increase in the second year (Table 3, 4).

The study carried out between April and May years of 2016 and 2017. The effects of 50, 100, 150 Mmol salt applications of Yedikule lettuce which has a high consumption rate in our country, were investigated.

It is stated that the salt stress applied in pepper reduce macro element content, stem and root fresh weight and dry weight (Ekbic et al., Tuna and Eroğlu 2017). In a study applied salt (0-50-100-150-200 mM) at different doses, germination rate, radicle length (cm), plumule length (cm), radicle fresh and dry weight (gr), and plumule fresh and dry weight (gr) were decreased (Ozkorkmaz and Yılmaz, 2017). It has been reported that salt stress decreased leaf water potency and leaf proportional water content while membrane damage index were increased in spinach (Deveci and Tuğrul, 2017). Pumpkin seed genotypes were shown to adversely affect plant development in saline soil conditions (Abdulhadi et al., 2017). The salt applied in pepper genotypes reduced flowering, photosynthesis, stomatal conductance, relative fresh shoots and fruit weights and water use efficiency (Baath et al., 2017). It has been reported that a significant reduction in yield of basil plant in increased salt content (Caliskan et al., 2017).

It was seen that the salt application decreased the K, Ca and Mg contents in Yedikule lettuce plant every two years. This shows that the ratio of K, Ca and Mg is decreased when the ratio of Na increases in the plant. It was stated that the Na and Cl ratios were increased in the salty water applied to cucumber (Usanmaz and Abak, 2018). Salt applications in tomato leaves indicated that the amount of N and P were increased and the amount of Mg, S, Fe, Mn were decreased (Korkmaz et al., 2017). In the okra plant applied salt stress, it was emphasized that fresh and dry weight, root fresh and dry weight, leaf number and leaf area, green component K and Ca content decreased and Na content increased (Kuşvuran, 2011). In study of application of salt and heat stress to Arabidopsis plants, it was emphasized that the amount of Na is increased and the amount of K is decreasing in the leaves of plants in salt (Suzuki et al., 2016). It has been stated that increasing salt doses reduce yield and quality in plants (Chaudhry et al., 2021; Miceli et al., 2021; Sogoni et al., 2021).

Table 1. Data of fresh weight (g), (%) membrane damage index and (%) leaf relative water content (%) of lettuce plant during the first year in salt stress condition.

Salt Doses	Plant Weight (g)	MDI (%)	LRWC (%)
0 mM	286.51 <sup>a</sup>	0.98 <sup>d</sup>	83.77 <sup>a</sup>
50 mM	217.28 <sup>b</sup>	33.81 <sup>c</sup>	67.71 <sup>b</sup>
100 mM	93.41 <sup>c</sup>	59.87 <sup>b</sup>	52.27 <sup>c</sup>
150 mM	54.86 <sup>d</sup>	68.54 <sup>a</sup>	46.22 <sup>c</sup>

P < 0.05

Table 2. Data of fresh weight (g), (%) membrane damage index and (%) leaf relative water content (%) of lettuce plant during the second year in salt stress condition.

Salt Doses	Lant Weight	MDI (%)	LRWC (%)
0 mM	395.24 <sup>a</sup>	1.64 <sup>d</sup>	86.63 <sup>a</sup>
50 mM	254.94 <sup>b</sup>	44.68 <sup>c</sup>	72.18 <sup>b</sup>
100 mM	70.57 <sup>c</sup>	65.54 <sup>b</sup>	46.42 <sup>c</sup>
150 mM	49.68 <sup>d</sup>	75.15 <sup>a</sup>	39.227 <sup>d</sup>

P < 0.05

Table 3. Content of K (%) Ca, (%) Mg and (%) Na of lettuce plant during the first year in salt stress condition.

Salt Doses	K	Ca	Mg	Na
0 mM	6.74 <sup>a</sup>	2.95 <sup>a</sup>	0.63 <sup>a</sup>	0.09 <sup>d</sup>
50 mM	6.08 <sup>b</sup>	2.32 <sup>b</sup>	0.43 <sup>b</sup>	0.33 <sup>c</sup>
100mM	5.82 <sup>c</sup>	2.01 <sup>c</sup>	0.39 <sup>bc</sup>	1.75 <sup>b</sup>
150 mM	5.77 <sup>c</sup>	1.82 <sup>d</sup>	0.37 <sup>c</sup>	1.90 <sup>a</sup>

P < 0.05

Table 4. Content of K (%) Ca, (%) Mg and (%) Na of lettuce plant during the second year in salt stress condition.

Salt Doses	K	Ca	Mg	Na
0 mM	6.83 <sup>a</sup>	2.88 <sup>a</sup>	0.79 <sup>a</sup>	0.16 <sup>c</sup>
50 mM	6.25 <sup>b</sup>	2.46 <sup>b</sup>	0.57 <sup>b</sup>	0.47 <sup>b</sup>
100 mM	5.63 <sup>c</sup>	2.12 <sup>c</sup>	0.42 <sup>b</sup>	1.83 <sup>a</sup>
150 mM	5.22 <sup>c</sup>	1.75 <sup>d</sup>	0.25 <sup>c</sup>	1.98 <sup>a</sup>

P < 0.05

As in many parts of the world, the surplus of salty land in our country also creates serious problem in production. As we have seen in our two-year study, increased salt doses affect negatively the yield and quality of the plant. Damage of 50, 100, 150 Mmol applications of salt was investigated in Yedikule lettuce variety, which is high in terms of consumption and production in our country. Among the amounts of salt applied in our study, it was observed that especially 150 Mmol of salt decreased the fresh weight of plant, leaf-proportional water content, K, Ca and Mg more than other salt amounts. However, it was observed that the increased amount of salt, whereas the amount of Na and leaf membrane damage index were increased, maximum increase was 150 Mmol salt application.

## Conclusion

In a two-year study conducted to determine the damage of salty environments in lettuce production, when the 50, 100 and 150 mM salt doses applied to the Yedikule lettuce variety were examined in two years, it was observed that there was a statistical difference. While plant weight decreased in both years, the highest weight loss was observed at 150 mM dose of salt. It was observed that the

membrane damage index increased with increasing salt doses, and the leaf relative water content decreased with increasing salt dose in both years. It was observed that potassium, calcium and magnesium contents decreased at 150 mM salt dose in both years, while Na content increased with increasing salt dose.

As a result of the study, it is seen that the yield and quality of the lettuce plant decrease with increasing salt doses. For this reason, it should be paid attention that the fertilizers applied in plant production should not disturb the structure of the production environment or soil.

## References

- Abdulhadi S, Seymen M, Turkmen Ö. 2017. Effect of Arbuscular Mycorrhiza Fungi application on seedling development in squash in saline soil conditions. *Manas Journal of Agriculture Veterinary and Life Sciences*, 7(2):1-12
- Baath GS, Shukla MK, Bosland PW, Steiner RL, Walker SJ. 2017. Irrigation water salinity influences at various growth stages of *Capsicum annum*. *Agricultural Water Management*, 179: 246-253.
- Bağcı EG. 2010. Identification of drought-induced oxidative stress in chickpea with physiological and biochemical parameters (unpublished Ph.D. Thesis). Ankara University Faculty of Science. 403 p
- Caliskan O, Kurt D, Temizel KE, Odabas MS. 2017. Effect of Salt Stress and Irrigation Water on Growth and Development of Sweet Basil (*Ocimum basilicum* L.). *Open Agriculture*, 2(1): 589-594.
- Chaudhry UK, Gökçe ZNÖ, Gökçe AF. 2021. Drought and salt stress effects on biochemical changes and gene expression of photosystem II and catalase genes in selected onion cultivars. *Biologia*, 76(10), 3107-3121
- Deveci M, Tuğrul B. 2017. Effect of salt stress on the leaf physiological properties of spinach. *Academic Journal of Agricultural Journal*, 6: 89-98
- Dinler BS, Cetinkaya H, Akgun M, Korkmaz K. 2021. Simultaneous Treatment of Different Gibberellic Acid Doses Induces Ion Accumulation and Response Mechanisms to Salt Damage in Maize Roots. *Journal of Plant Biochemistry and Physiology*, 9: 258.
- Ekbic E, Cagıran C, Korkmaz K, Kose MA, Aras V. 2017. Assessment of watermelon accessions for salt tolerance using stress tolerance indices. *Ciência e Agrotecnologia*, 41: 616-625.
- Jebara S, Jebara M, Limam F, Aouani ME. 2005. Changes in ascorbate peroxidase, catalase, guaiacol peroxidase and superoxide dismutase activities in common bean (*Phaseolus vulgaris*) nodules under salt stress. *Journal of Plant Physiology*, 162(8): 929-936.
- Kabay T. 2018. Farklı tuz dozlarında üretilen marulda humik asitin bitki gelişimine etkisi. *Ejons*, 5(2): 37-43.
- Kabay T, Erdiñ Ç, Şensoy S. 2017. Effects of drought stress on plant growth parameters membrane damage index and nutrient content in common bean genotypes. *The Journal of Animal and Plant Sciences*. 27(3): 940-952
- Kabay T, Şensoy, S. 2017. Enzyme, chlorophyll and ion changes in some common bean genotypes by high temperature stress. *Ege University Journal of Agricultural Sciences*, 54(4): 429-437.
- Kabay T, Şensoy S. 2016. Drought stress-induced changes in enzymes, chlorophyll and ions of some bean genotypes. *Yuzuncu Yıl University Journal of Agricultural Sciences*, 26(3): 380-395.
- Kıran S, Kuşvuran Ş, Özkay F, Özgün Ö, Sönmez K, Özbek H, Ellialtıođlu ŞŞ. 2015. Bazı patlıcan anaçlarının tuzluluk stresi koşullarındaki gelişmelerinin karşılaştırılması. *Tarım Bilimleri Araştırma Dergisi*, 8(1): 20-30.
- Korkmaz A, Karagöl A, Akınođlu G, Horuz A. 2017. Effects of application of CaCl<sub>2</sub> in soilless culture on macro and micro nutrient contents of tomato plant grown under NaCl stress conditions. *Journal of Soil Science and Plant Nutrition* 5(1): 1-8
- Korkmaz K, Akgün M, Kırılı A, Özcan MM, Dede Ö, Kara ŞM. 2020. Effects of gibberellic acid and salicylic acid applications on some physical and chemical properties of rapeseed (*Brassica napus* L.) grown under salt stress. *Turkish Journal of Agriculture-Food Science and Technology*, 8(4): 873-881.
- Kuşvuran Ş, Ellialtıođlu Ş, Daşgan HY, Abak K. 2012. Tuzlu koşullara toleransı yüksek bazı yerli kavun aksesyonları. *Türk Bilimsel Derlemeler Dergisi*, (2): 151-153.
- Kuşvuran Ş. 2011. Bamyada (*Abelmoschus esculentus* L.) da tuz stresine tolerans bakımından genotip sel farklılıklar ve tarama parametrelerinin araştırılması. *Derim*, 28(2): 55-70.
- Kuşvuran Ş. 2010. Relationships between physiological mechanisms for drought and salinity tolerance of melons (unpublished Ph.D. Thesis). Çukurova university institute of Natural and Applied Sciences. 356 p.
- Miceli A, Moncada A, Vetrano F. 2021. Use of microbial biostimulants to increase the salinity tolerance of vegetable transplants. *Agronomy*, 11(6): 1143.
- Ozkorkmaz F, Yılmaz N. 2017. Beans of Different Salt Concentrations (*Phaseolus vulgaris* L.) and Borulcede (*Vigna unguiculata* L.) determination of effects on germination. *Ordu Üniversitesi Bilim ve Teknoloji Dergisi*, 7(2): 196-200.
- Sogoni A, Jimoh MO, Kambizi L, Laubscher CP. 2021. The impact of salt stress on plant growth, mineral composition, and antioxidant activity in tetragonia decumbens mill.: An underutilized edible halophyte in South Africa. *Horticulturae*, 7(6): 140
- Suzuki N, Bassil E, Hamilton JS, Inupakutika MA, Zandalinas SI, Tripathy D, Nakano R. 2016. ABA is required for plant acclimation to a combination of salt and heat stress. *PLoS One*, 11(1): 0147625.
- Tuna AL, Erođlu B. 2017. Some organic and inorganic compounds affect the antioxidative system of pepper (*Capsicum Annum* L.) under salt stress. *Anatolian Journal of Agricultural Sciences*, 32(1): 121-131.
- Usanmaz S, Abak K. 2018. Plant growth and yield of cucumber plants grafted on different commercial and local rootstocks grown under salinity stress. *Saudi Journal of Biological Sciences*. 26(6): 1134-1139.
- Yeşilova A, Denizhan E. 2016. Modelling mite counts using poisson and negative binomial. *Fresenius Environmental Bulletin*. 25:5062-5066.