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Research Article

# Determining Salt Tolerance of Zinnia Flower

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## Abstract

In this study, it was aimed to determine the effects of irrigation water containing different salt levels on the morphological characteristics of zinnia (*Zinnia elegans*). For this purpose, five different salt levels (control (tap water), 2 dS $m^{-1}$, 4 dS $m^{-1}$, 6 dS $m^{-1}$ and 8 dS $m^{-1}$) were established. As morphological characteristics, plant height, plant diameter, number of flowers, flower diameter, flower stem length, flower stem diameter, petal number, petal length, petal width, leaf thickness, leaf length and leaf width were measured. Irrigation was carried out at 7-day intervals. Soil moisture was monitored with pot weights. The research was carried out in Çanakkale Onsekiz Mart University, Faculty of Agriculture, Crop Stress Monitoring and Thermography Laboratory (COSMOTLAB) in 2020.

As a result of the study, while the number of flowers, flower diameter, number of petals, leaf thickness, leaf length and leaf width values of morphological features were found to be statistically different according to salt levels; plant height, plant diameter, peduncle length, peduncle diameter, petal length and petal width were found to be insignificant. When evaluated in terms of visual appearance, it can be said that there are significant differences between the treaments depending on the level of salt stress. According to the results of the research, it was revealed that the salt tolerance of the zinnia flower was partially low.
**Keywords:** Zinnia, salt stress, ornamental plant, morphological features

## Zinya Çiçeğinin Tuz Toleransının Belirlenmesi

## Öz

Bu çalışmada, farklı tuz düzeyleri içeren sulama sularının zinya çiçeğinin (*Zinnia elegans*) morfolojik özelliklerine etkilerinin belirlenmesi amaçlanmıştır. Bu amaçla beş farklı tuz düzeyi (kontrol (şebeke suyu), 2 dS $m^{-1}$, 4 dS $m^{-1}$, 6 dS $m^{-1}$ ve 8 dS $m^{-1}$) oluşturulmuştur. Morfolojik özellikler olarak bitki boyu, bitki çapı, çiçek sayısı, çiçek çapı, çiçek sap uzunluğu, çiçek sap çapı, petal sayısı, petal uzunluğu, petal eni, yaprak kalınlığı, yaprak uzunluğu ve yaprak eni ölçülmüştür. Sulamalar 7 gün aralıklarla yapılmış ve toprak nemi saksı ağırlıklarıyla izlenmiştir. Araştırma, 2020 yılında Çanakkale Onsekiz Mart Üniversitesi, Ziraat Fakültesi, Bitki Stresi İzleme ve Termografi Laboratuvarında (BİSİTLAB) yürütülmüştür.

Çalışma sonucunda, morfolojik özelliklerden çiçek sayısı, çiçek çapı, petal sayısı, yaprak kalınlığı, yaprak uzunluğu ve yaprak eni değerleri tuz düzeylerine göre istatistiksel olarak farklı bulunurken; bitki boyu, bitki çapı, çiçek sap uzunluğu, çiçek sap çapı, petal uzunluğu ve petal eni ise önemsiz bulunmuştur. Görsel görünüm açısından değerlendirildiğinde ise tuz stresi düzeyine bağlı olarak konular arasında farkların belirgin biçimde ortaya çıktığı söylenebilir. Araştırma sonucuna göre zinya çiçeğinin tuz toleransının kısmen düşük olduğu ortaya çıkmıştır.
**Anahtar Kelimeler:** Zinya, tuz stresi, süs bitkisi, morfolojik özellikler

## Introduction

In the past, water quality problems have generally been neglected because of the sufficient availability of quality water resources and the fact that they were obtained without difficulty. However, as a result of global warming and the increasing world population, the demand for water has increased the pressure on existing resources and the water supply has been insufficient to meet this demand. As a result of the intensive use of almost all quality water resources, irrigation with low quality irrigation water has become mandatory (Malakar et al., 2019).

Irrigation water contains more or less dissolved solids, namely salts, depending on the source it comes from. Salinity is one of the most important stress factors threatening crop production today (Akçal and Kaynaş, 2021). The use of irrigation water for many years without taking precautions causes the salinity to increase in the root zone of the plant, causing toxic effects on the grown plants and adversely affecting the physical properties of the soil (Richards, 1954; Rhoades et al., 1973; Maas and Hoffman, 1977; Karakoç and Kale, 2016). Along with the increase in the salt concentration in the soil, deterioration in the soil structure creates problems in the water uptake in the root zone of the plants and accordingly the plant growth slows down (Kanber and Ünlü, 2010; Akçaman et al., 2017). Salt stress limits crop productivity by affecting the growth of plants, especially in arid and semi-arid climates. 10 million hectares of land are lost every year in the world due to salinity (Akgül, 2003; Özkorkmaz and Yılmaz, 2017). Salt tolerance of plants varies. Salt sensitive plants make an uncontrolled ion uptake in salty environments. Since these plants do not have parts to store the high amount of salt taken, they cause damage to the plant (Deliboran and Savran, 2015).

In recent years, plant species with high resistance to drought and salinity are preferred in landscaping where outdoor ornamental plants are used (Akçal and Kaynaş, 2021). Zinnia is an annual species naturally found in Central America and Mexico, belonging to the Asteraceae family. There are some varieties as well as layered and small flowers in different colors. It is easy to cultivate, requires effortless cultural care and is disease resistant; For these reasons, it is widely used in landscaping (Dole, 1999; Demirel et al., 2021).

Although there are many international studies on zinnia, studies on the effects of different salt applications on the morphological characteristics of zinnia have been limited as only a few features have been examined. In this study, the effects of different salt levels on morphological features were investigated in order to determine the salt tolerance of zinnia.

## Material and Method

### Study Area

The study, Çanakkale Onsekiz Mart University, Faculty of Agriculture, Crop Stress Monitoring and Thermography Laboratory (COSMOTLAB) in 2020, zinnia (*Zinnia elegans*) was used as plant material (Figure 1).

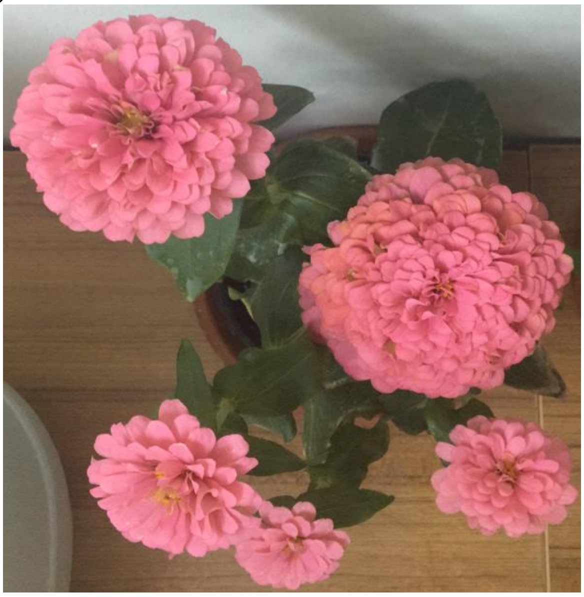

Figure 1. *Zinnia elegans*

The research was carried out under control conditions (25 ˚C±2 temperature, 40±3% humidity and 16/8 photoperiod). Planting was carried out with 1 zinnia flower in each pot with a 1:1 mixture of peat and perlite. In the study, a control treament and a total of five irrigation treaments with four different salt levels were formed (Table 1).

Before setting up the experiment, the pot capacity (field capacity) and the usable water holding capacity (UWHC) of each pot were determined (Camoglu, 2013; Demirel et al., 2020). In the first irrigation together with planting, all treaments were carried out equally with the tap water to be completed to the pot capacity. Afterwards, all treaments were irrigated with reference to the control treament, at 7 days intervals, in such a way that the reduced moisture in the pot was completed to 100% of the usable water holding capacity. With the second irrigation, the implementation of the treaments started. All treatments consisted of 4 replicates and a total of 20 pots were used, 1 plant in 1 pot in each replicate. Irrigation of the control treament was made from tap water and its electrical conductivity (EC) was measured 0.7 dS $m^{-1}$.

Table 1. Salt levels treaments

| Treaments | Salt Levels |
|---|---|
| S-0 | Control (tap water) |
| S-2 | 2 dS $m^{-1}$ |
| S-4 | 4 dS $m^{-1}$ |
| S-6 | 6 dS $m^{-1}$ |
| S-8 | 8 dS $m^{-1}$ |

**Morphological Measurements**

Throughout the experiment, measurements were made at seven-day intervals and before irrigations. The measurements started on the day of planting and continued until the 42nd day after planting ($DAP_{42}$). Within the scope of the study, morphological measurements were made 7 times in total. These measurements were evaluated in 4 main sections (plant, flower, petal, leaf).

**Plant properties;**

Plant height (cm): It was measured with the help of a ruler from the growing medium to the top of the plants.

Plant diameter (cm): It was measured as the distance between the extreme points of the plants when viewed from the top.

**Flower properties;**

Number of flowers (pieces $plant^{-1}$): It was obtained by counting the open flowers on the plant after the dried flowers were removed.

Flower stem length (cm): It was measured as the distance of the flower stalk from the soil level to the flower tray.

Flower stem diameter (mm): It was measured from the thickest part of the flower stalk with the help of callipers.

Flower diameter (mm): It was measured from the outermost part of the opened flowers with callipers.

**Petal properties;**

Petal number (pieces/plant): It was obtained by counting the petals of the opened flowers.

Petal length (mm): Petal length of opened flowers was measured with callipers.

Petal width (mm): Petal leaf width of opened flowers was measured with callipers.

**Leaf properties;**

Leaf length (cm): The leaves of the plant were measured with the help of a ruler from the outlet to the tip.

Leaf width (mm): It was measured with callipers from the widest part of the leaf width.

Leaf thickness (mm): It was measured with callipers from the place where the leaf thickness was the greatest.

**Statistical Analysis**

One-way analysis of variance (One-Way ANOVA) was used to determine whether the difference between the data obtained as a result of the treatments in the experiment was significant

($p=0.05$). If the difference was significant, Duncan test was performed to determine the difference between the treatments. All statistical evaluations were made with the help of SPSS 20.0 package program.

## Results and Discussion

### Morphological measurements

The results obtained within each main group are discussed below under separate headings.

### Plant Properties

When plant height was analysed, the highest plant height was observed in S-8 and the lowest plant height was observed in S-0 in DAP42 (Figure 2a). After DAP35, plant height decreased in all treatments except S-0 and S-2 treatments until the end of the experiment. Markovic et al. (2022) reported a decrease in plant height against increasing salt levels in zinnias at four different salt levels (control, 3 dS $m^{-1}$, 4.5 dS $m^{-1}$, 6 dS $m^{-1}$). Niu et al. (2012) reported that plant height decreased with increasing salt level in Zinnia (Zinnia marylandica) flower at 5 different salt levels (control, 3 dS $m^{-1}$, 4.2 dS $m^{-1}$, 6 dS $m^{-1}$ and 8 dS $m^{-1}$). Bizhani et al. (2013) applied seven different salt levels (0 dS $m^{-1}$, 2.5 dS $m^{-1}$, 5 dS $m^{-1}$, 7 dS $m^{-1}$, 7.5 dS $m^{-1}$, 10 dS $m^{-1}$ and 15 dS $m^{-1}$) on zinnias. As a result, these researchers also reported an inverse relationship between increasing salt level and plant height. These findings are different from the results of our study. It can be said that the difference between the above-mentioned studies and this study is due to the difference in growing medium and zinnia flower varieties.

Plant diameter values were highest in S-0 and lowest in S-8 (Figure 2b). All treaments showed close values until $DAP_{28}$. However, after $DAP_{42}$, the effect of salt level on plant diameter became quite significant.

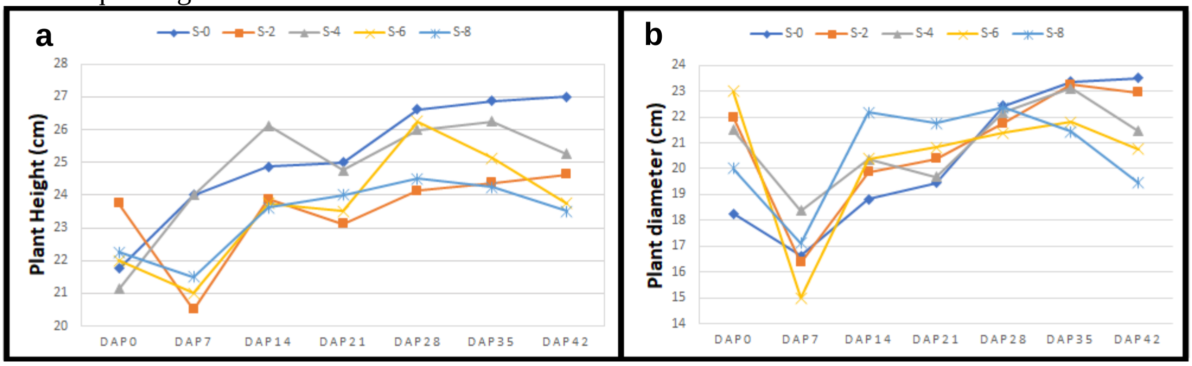


Figure 2. Plant height(a), plant diameter(b)

The results of statistical analysis of the averages of the measurements of plant traits within the scope of the study are given in Table 2. When plant height and plant diameter were analysed according to salt levels, the differences between all treatments were found statistically insignificant.

Table 2. Plant height, plant diameter in irrigation treaments with salt levels

| Treaments | Plant Height (cm) | Plant Diameter (cm) |
|---|---|---|
| S-0 | 25.2±0.4NS | 20.3±0.3NS |
| S-2 | 23.5±0.8NS | 20.8±0.5NS |
| S-4 | 24.8±1.1NS | 21.4±0.1NS |
| S-6 | 23.6±1.1NS | 20.1±0.5NS |
| S-8 | 23.4+1.1NS | 20.7±0.5NS |

**Flower Properties**

When flower number values were analyzed, the values of all treatments were similar until $DAP_{14}$ (Figure 3a). The highest values were measured in S-0 and S-2. The other treatments differed from each other in terms of flower number and had lower values. Markovic et al. (2022) also reported a linear decrease in the number of flowers in response to increasing salt levels in zinnias at four different salt levels (control, 3 dS $m^{-1}$, 4.5 dS $m^{-1}$, 6 dS $m^{-1}$). The results obtained in this study are similar to those of the aforementioned study.

When flower diameter values were analyzed, all treaments showed a decreasing trend in $DAP_{42}$ (Figure 3b). However, a greater decrease in flower diameter value occurred in S-8 (Figure 3b). There was a noticeable difference between the treaments due to the increase in salt level. Bizhani et al. (2013) reported that flower diameter decreased by 75% at 10 dS $m^{-1}$ salt level compared to 0 dS $m^{-1}$. This study is similar to the aforementioned study.

When flower stem length was analysed, S-2 differed from the other treatments and had the highest values in all measurements (Figure 3c). It can be said that flower stem length decreased as the salt level increased. When flower stem diameter values were analysed, it was observed that all subjects showed a similar trend (Figure 3d). The highest value was observed in S-4 and the lowest value was observed in S-6. It can be said that salt level has no direct effect on flower stem diameter.

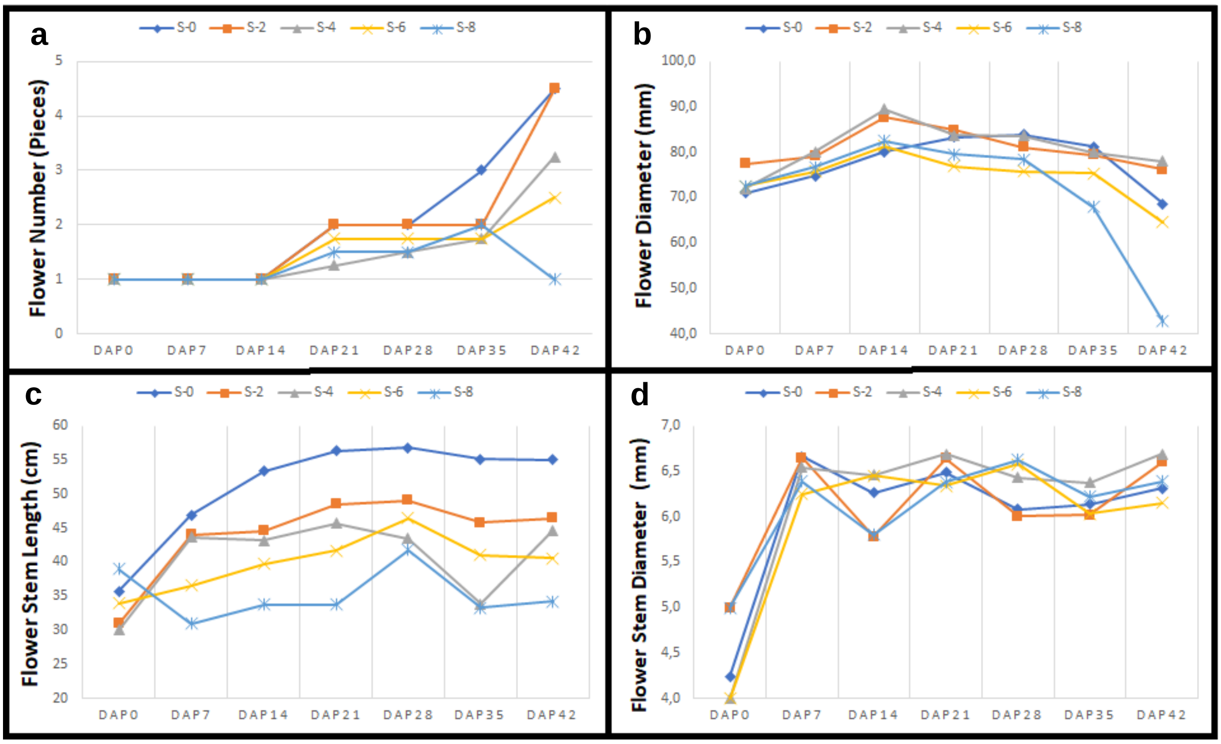

Figure 3. Number of flowers(a), flower diameter(b), flower stem length(c), flower stem diameter(d)

The results of the statistical analysis of the measurements of flower characteristics are given in Table 3. When the number of flowers was analyzed, no statistically significant difference was found between S-0 and S-2 treatments and S-4 and S-6 treatments. However, a statistically significant difference was found between S-0 and S-2 treaments and S-8 treament. When flower diameter was analyzed, S-2 and S-4 treatments had the highest values, while S-8 treatment had the lowest value. Statistically, S-0 was similar to S-2, S-4 and S-6, but different from S-8.

Table 3. Flower number, flower diameter, flower stem length, flower stem diameter in irrigation treaments with salt levels

| Treaments | Flower Number (pieces) | Flower Diameter (mm) | Flower Stem Length (mm) | Flower Stem Diameter (mm) |
|---|---|---|---|---|
| S-0 | 2±1A | 78±09AB | 51.3±3.4NS | 6.0±0.2NS |
| S-2 | 2±3A | 81±1A | 46.4±5.8NS | 6.2±0.01NS |
| S-4 | 2±2AB | 82±1.3A | 42.1±6.6NS | 6.4±1NS |
| S-6 | 2±2AB | 75±1.5BC | 40.8±5.8NS | 6.2±4NS |
| S-8 | 1±1 B | 71+2.2C | 34.4±3.9 NS | 6.3±2NS |

When flower stem length and flower stem diameter were analyzed, no statistical difference was found between all treatments.

**Petal Properties**

When the number of petals was analysed, all treatments showed a similar trend until DAP21, after this date, S-6 and S-8 treatments started to decrease (Figure 4a).

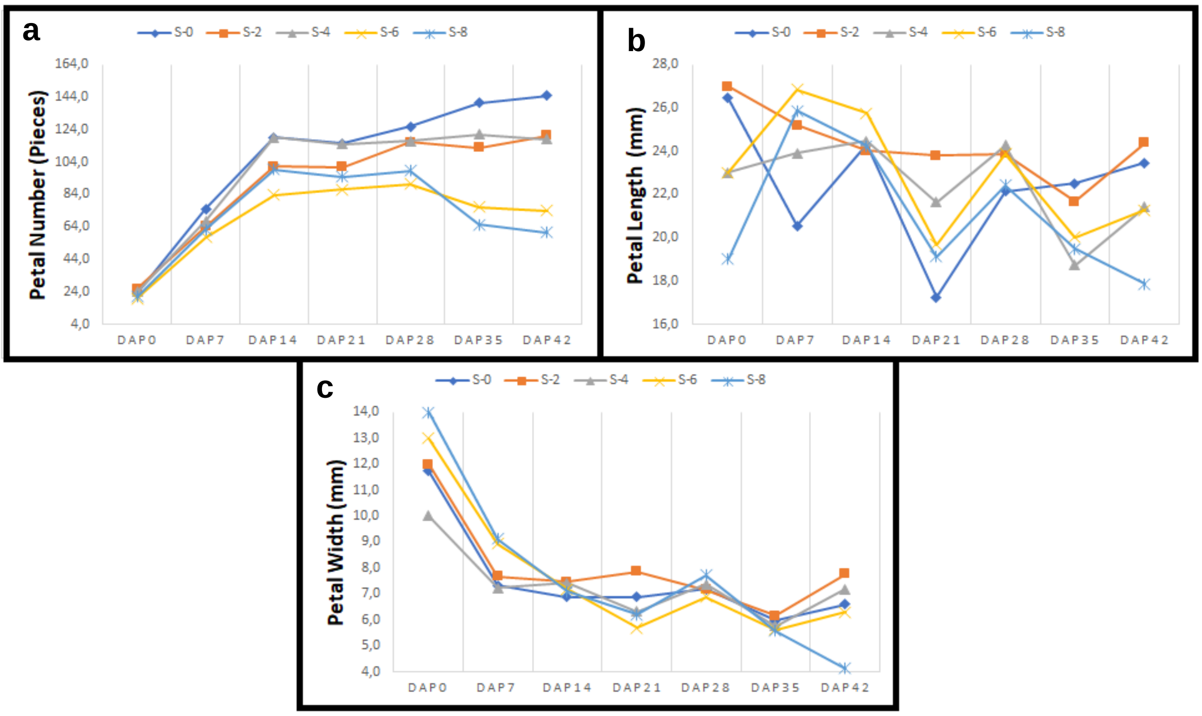


Figure 4. Petal number(a), petal length(b), petal width(c)

When the petal length values were analyzed, the highest value was measured in S-2 and the lowest in S-8 (Figure 4b). In the last measurement, while the values of all treaments increased compared to the previous week, there was a decrease in treament S-8. It can be said that this situation is due to the termination of vegetative activities in S-8 due to salt. When petal width was analyzed, all treaments generally showed the same trend throughout the whole measurement period (Figure 4c). In the second measurement, $DAP_7$, a decrease occurred in all values in all treaments and continued close to these values until the end of the experiment.

The results of statistical analysis of the averages of the measurements of petal properties within the scope of the study are given in Table 2.

Table 4. Petal number, petal length, petal width in irrigation treaments with salt levels

| Treaments | Petal Number (pieces) | Petal Length (mm) | Petal Width (mm) |
|---|---|---|---|
| S-0 | 100±5.4AB | 22.4±0.8NS | 7.5±0.3NS |
| S-2 | 95±8AB | 23.9±1.3NS | 7.5±0.2NS |
| S-4 | 104±4.3A | 22.4±0.5NS | 7±0.2NS |
| S-6 | 77±6.7C | 22.9±0.5NS | 7±0.4NS |
| S-8 | 82±7.4BC | 21.4±0.5NS | 6.9±0.4NS |

When the petal number change was analyzed according to the treaments, it was found to be statistically significant. petal number and petal width values were found to be statistically insignificant among the treatments.

**Leaf Properties**

When leaf thickness was analyzed, a decrease was observed in $DAP_7$ at the same level in all treaments (Figure 5a). In DAP42, all treaments showed an increasing trend, while a decrease was observed in S-8. When leaf length was analyzed, all treaments showed a similar trend in general (Figure 5b). While all treaments decreased in DAP42, S-2 treament remained constant. When leaf width values were analyzed, the lowest value was found in S-8 and the highest value was found in S-0 (Figure 5c).

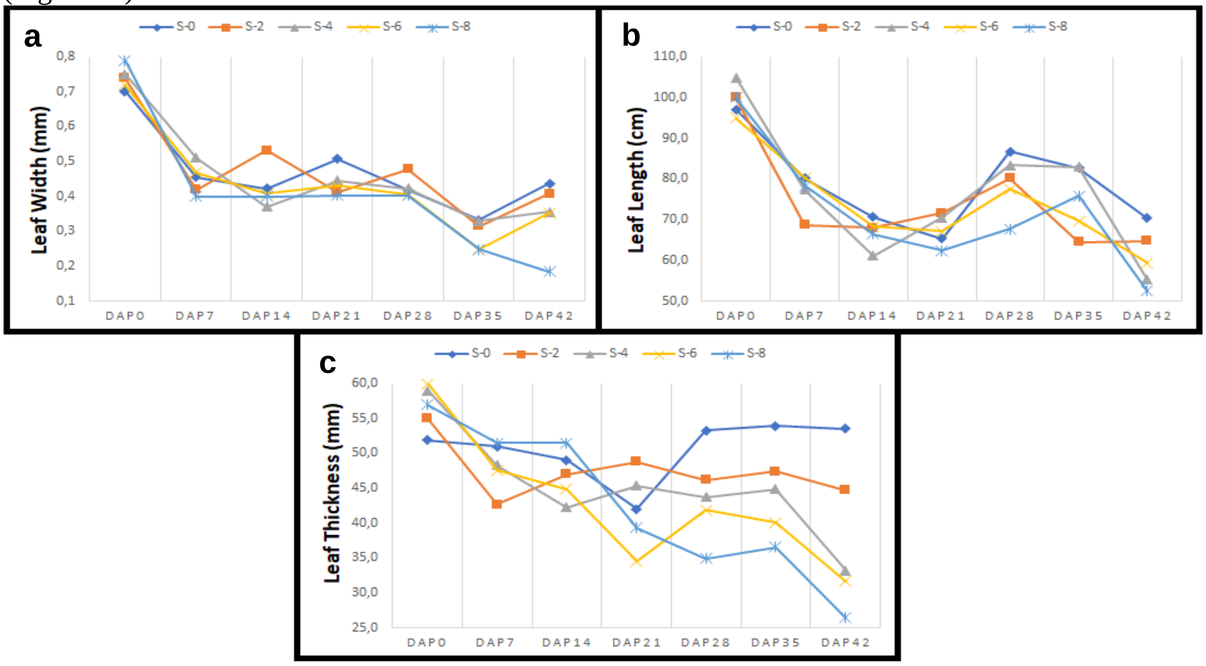


Figure 5. Leaf width(a), leaf length(b), leaf thickness(c)

The results of statistical analysis of leaf characteristics are given in Table 5. When leaf thickness values were analyzed, it was determined that there were statistically significant differences among the treaments. While there was no statistical difference between S-0 and S-4 in leaf length values, there was no statistical difference between S-2, S-4, S-6 and S-8. When leaf width was analyzed, S-0 was found to be statistically different from all treaments except S-2.

Yasemin and Koksal (2023) found statistically insignificant effect on leaf length and leaf width in 2 different zinnia flowers at 5 different salt levels. However, it can be said that the difference between the mentioned study and this study is due to the variety.

Table 5. Leaf width, leaf length, leaf thickness in irrigation treaments with salt levels

| Treaments | Leaf Width (mm) | Leaf Length (mm) | Leaf Thickness (mm) |
|---|---|---|---|
| S-0 | 0.47±0.02A | 79±1.8A | 50.7±0.9A |
| S-2 | 0.44±0.02AB | 70.7±1.4B | 46.4±2.2AB |
| S-4 | 0.42±0.02AB | 72.8±3.5AB | 43.3±3.1B |
| S-6 | 0.40±0.02BC | 71.3±1.1B | 40.8±1.3B |
| S-8 | 0.36±0.02C | 68.5±3.2B | 40.7±1.2B |

As a result of the experiment, the effect of different salt levels on zinnia flower is shown respectively (Figure 6). While S-0 and S-2 treatments maintained their visual vigor, S-4, S-6 and S-8 treatments lost their visual vigor and dried up due to the increase in salt level. In the study, there was no statistical difference between the treaments in morphological measurements (plant height, plant diameter), but the differences were clearly seen visually (Figure 6). Yasemin and Koksal (2023) in their study, decreases in visual appearance occurred due to the increase in salt level. It was reported that the growth of the plants stopped and drying occurred with the effect of salt and a similar process was observed in the present study. This study is similar to the aforementioned study.

Figure 6. Final visual status of the treaments according to salt levels

**Conclusions**

In the study conducted to determine the salt tolerance of zinnia flower (*Zinnia elegans*), it was concluded that different salt levels affected the morphological characteristics of zinnia flower. Since flower number, flower diameter, petal number, petal length, leaf length, leaf width and leaf thickness traits were affected by increasing salt level, statistical differences were found among the subjects. It can be said that these traits responded more quickly to salt stress. The S-8 treament with the highest salt level was found to have the lowest values in all parameters except flower stem diameter. Since visuality is at the forefront in ornamental plants, it was determined that the lowest salt level of 2 dS $m^{-1}$ affected the visuality to a small extent and this effect started to be seen after $DAP_{35}$.

As a result of the study, it was determined that zinnia flower, which is frequently used in landscaping applications, is not tolerant to salt stress and this causes a decrease or termination of vegetative activities.

**Authors' Contributions**

All authors have participated sufficiently in the work take responsibility for the content.

**Conflicts of Interest Statement**

The authors declare no competing interests.

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