# Effect of Different Levels of Saline Irrigation Water and Potassium application on Some Chemical Properties of Three Varieties of Turfgrasses

**Tezhraw M. Amin[1]** **Dalshad R. Azeez[1]** **Ala'a H. A.-Q. Al-Bakkar[1]**

**[1] University of Kirkuk – College of Agriculture**
**Research is part of a master's thesis for the first researcher**

## Abstract

This study was conducted at the Research Station and Agricultural Experimentation – College of Agriculture - Kirkuk University during the agricultural season 2018 on three varieties of turfgrass, one of which is winter turfgrass (Tall fescue) and two of which are summer turfgrass (Argentina Bahiagrass and Bermudagrass), irrigated by four different levels of irrigation water (1.7, 5, 10, and 15 dS/m) and two levels of Potassium ($K_2SO_4$) fertilizer (zero and recommended) , in order to determine the effect of different varieties and application of potassium fertilization on turfgrass tolerance to irrigation water salinity. Results showed the difference of the three varieties in their ability to tolerate salinity, where Tall fescue surpassed the other two. It was also found that increasing the salinity levels of irrigation water resulted in increasing the content of the leaves of proline and sodium. No significant effect was observed on leaf content of chlorophyll. Potassium fertilization resulted in a negligible increase in leaf content of proline, sodium, potassium and chlorophyll.

**Keywords: Turfgrass, irrigation water salinity, potassium fertilization, proline**

---

# تأثير مستويات مختلفة من مياه الري المالحة واضافة البوتاسيوم في بعض الصفات الكيميائية لثلاثة اصناف من المسطحات الخضراء

**تيژره و محمد أمين [1]** **دلشاد رسول عزيز [1]** **علاء حسين عبدالقادر [1]**

**[1] جامعة كركوك - كلية الزراعة**
**البحث مستل من رسالة ماجستير للباحث الاول**

## الخلاصة

اجريت هذه الدراسة في محطة البحوث والتجارب الزراعية - كلية الزراعة – جامعة كركوك خلال الموسم الزراعي 2018 على ثلاثة اصناف من المسطحات الخضراء احداها شتوية (Tall fescue) واثنان منها صيفية (Argentina Bahiagrass و Bermudagrass)، استخدم في سقيها اربعة مستويات مختلفة من مياه الري (1.7 و 5 و 10 و15 دسيسمنز\م) و مستويين من السماد البوتاسي $K_2So_4$ ( صفر و الموصى بها) وذلك بهدف معرفة تاثير اختلاف الاصناف واضافة التسميد البوتاسي في تحمل المسطحات الخضراء لملوحة مياه الري. اظهرت النتائج اختلاف الاصناف الثلاثة في قدرة تحملها للملوحة وتفوق الصنف Tall fescue على الصنفين الاخرين.كما تبين ان زيادة مستوى ملوحة مياه الري ادت الى زيادة محتوى الاوراق من البرولين والصوديوم ولم يلاحظ تاثير معنوي في محتوى الاوراق من الكلوروفيل .كما ادى التسميد بالبوتاسيوم الى زيادة غير معنوية في محتوى الاوراق من البرولين والصوديوم والبوتاسيوم والكلوروفيل.

**الكلمات المفتاحية : المسطحات الخضراء ، ملوحة مياه الري ، التسميد البوتاسي ، البرولين**

---

## Introduction

Turfgrasses are defined as specific areas of land covered by short grass plants strumming on the ground and bear the burden of it, grow beside each other consisting of branches and dense leaves .Its growth is constantly renewed, as a result of systematic cutting operations at a height of 2-5 cm, at intervals of 10-30 times a year (Borchardt, 1999). Researches and studies point to the environmental importance of the turfgrass in improving the conditions of the environment and its surrounding by softening the general climate within the cities and creating a refreshing and clean atmosphere by releasing water vapour through the process of transpiration through the leaves, where it is found at the University of Texas that the space of the turf grass covering a football field reducing temperature and air cooling equivalent to the capacity of industrial air conditioners of 70 hp.( (Ahmed and Hassan, 2003 ; Tapia Silva, 2002). The turfgrass species are in the family Poaceae which was formerly known as Gramineae under the class Monocotyledoneae. More than 800 genera comprising over ten thousand species belong to the Poaceae (Piperno and Sues, 2005). Each species may contain a number of varieties or varieties. Most varieties are produced by hybridization followed by natural selection and also artificial selection. In consideration of life cycle, annual and perennial turfgrasses are available throughout the ecosystems (Prasad *et al*., 2005). Salinity inhibits seed germination, plant growth and affects the leaf anatomy and physiology of plants and, thereby, influences their photosynthesis, water relations, protein synthesis, energy production and lipid metabolism (Parida and Das, 2005).Salinity causes a major environmental problem limiting plant growth and productivity of both irrigated and non irrigated lands in many areas of the world and include imposition of ion toxicities (e.g., Na and Cl), ionic imbalances, osmotic stress, and soil permeability problems (Ashraf *et al*., 2008). In general, salt tolerance in plants is associated with low uptake and accumulation of Na, which is mediated through the control of influx and/or by active efflux from the cytoplasm to the vacuoles and also back to the growth medium (Jacoby,1999). Physiological responses to salinity include growth suppression and lowered osmotic potential (Marcum, 2006). Salt tolerant plants have the ability to minimize these detrimental effects by producing a series of morphological, physiological and biochemical processes (Jacoby, 1999). There are a number of potential turfgrass species that may be appropriate at various salinity levels of seawater. The demand for salinity-tolerant turfgrasses is increasing due to augmented use of effluent or low-quality water for turfgrass irrigation (Harivandi *et al*., 1992). A new generation of turf varieties allows landscape development in saline environments (Hester, et al, 2001; Gulzar, et al, 2003). Such type of several grasses has now been developed and selected to produce plant varieties that can be utilized as turf. These turfs are ideal in environments in which salinity is a problem or where limited or no fresh water is available for irrigation. During the onset and development of salinity stress within a plant, all the major processes, including photosynthesis, protein synthesis, as well as energy and lipid metabolism, are affected (Parida and Das, 2005). Plants experience water stress during the initial exposure of salt, followed by leaf expansion reduction (Carillo *et al*., 2011). The osmosis effects of salinity stress continue along with the duration of exposure, leading to inhibited cell expansion, cell division, and stomatal closure (Flowers, 2004; Munns, 2002; Carillo *et al*., 2011). In Bermudagrass and other turfgrass species it was found that proline and glycine betaine levels increased as salinity increased (Munshaw *et al*., 2004; Uddin and Juraimi, 2012). Most of the salt-tolerant plants can still function by maximizing water uptake and turgor pressure meaning that water relations are important for negating salinity stress. Salt-tolerant turfgrasses have the ability to minimize the detrimental effects by producing a series of anatomical, morphological, and physiological adaptations. Plants have developed diverse strategies to resist salt stress, such as restricting $Na^+$ uptake, activating $Na^+$ exclusion or cellular compartmentalization of excessive $Na^+$ into the vacuole (Hasigawa *et al*., 2000; Yang *et al*,. 2012). Potassium is an important component of a turfgrass fertility program. Although effects of K application may not be readily evidenced through increased turf shoot growth or darker green leaf color, K can reduce numerous stresses on turf. One of the primary ways that K reduces turf stress is through regulation of stomatal functioning, which enhances shoot water potential of the turfgrass plant. $K^+$ deficiency can usually be observed under salinity stress (Trenholm *et al*., 2001). Water scarcity is a growing problem. Finding ways to satisfy the need of water for human activities while at the same time protecting the freshwater systems, now ranks among the 21st century's most critical challenges. Government-mandated water use restrictions are widely spreading, requiring use of well water due to the increasing demands on limited potable water resources (Marcum, 2006). Well water, in general, has a higher salinity level than fresh water. Salinity tolerant plants can minimize saline stress effects by generating a series of processes at the morphological, physiological and biochemical levels (Jacoby, 1999; Uddin *et al*., 2011). Saline tolerant turfgrass could be used in areas where well water is used as the irrigation source or where saline soil issues exist (Uddin *et al*., 2011). For the purpose of adapting to well(saline) water and its use in irrigating the turfgrass , this study was conducted to determine the relative salt tolerance and growth response of warm and cool season turfgrass species and selection of the most suitable varieties of turf grass for cultivation in Kirkuk –Iraq and the extent of their tolerance to salinity of irrigation water.

## Materials and Methods

This study was conducted at the Research Station and Agricultural Experimentation – College of Agriculture - Kirkuk University , during the agricultural season 2018 , on three varieties of turfgrasses including winter turfgrass Tall fescue *Festuca arundinacea* (V1) and two summer turfgrasses including Argentina Bahiagrass *Paspalum notatum* (V2) and Bermudagrass *Cynodon dactylon* (V3) .All turfgrasses irrigated by four different levels of saline irrigation water S1, S2, S3, and S4, the electrical conductivity for each treatment was (1.7, 5, 10, and 15 dS/m) respectively. Two levels of Potassium (K2So4) fertilizer applicated, Zero (K0) and recommended (K1), in order to determine the effect of different varieties and application of potassium fertilization on turfgrass tolerance to irrigation water salinity. Randomize Complete Block Design (RCBD) was used for a factorial experiment with three factors (3*4*2) with three replicates for each treatment, thus, the number of experimental units reached 72 units, and each area of experimental units was 1.5 m * 1.5 m. A distance of 1.5 m was left between the experimental units for agricultural service operations including fertilizer applications, weeding, pest control and...etc. 75 g of each variety was cultivated in the experimental unit in 7/3/2018 , Potassium fertilizer was added by zero and the recommended amount of 4.5 g per experimental unit. The plants were irrigated for four weeks with normal water (control) to prevent plants from shocking, and then irrigation was started with four salt treatments for eight weeks, during this period the plants were cut twice to a length of 3cm. After the end of the experiment on 7/6/2018, samples of soft plant leaves were taken for the estimation of chlorophyll by the (Arnon, 1949) method, and Proline was estimated by (Bates, 1973) method. A sample of the soft plant was dried in a 65 °C for 72 hours, and 0.4 g of it was digested with concentrated sulphuric acid and perchloric acid, then K and Na were determined using flame photometer (Model No. 1381).

## Results and Discussion

### Leaves content of proline (µmol/g):

The results in Table (1) show that there are significant differences in proline leaves content among the varieties ( V ), where it reached the highest average of Proline in Tall fescue (V1) 312.3 µmol/g followed by the Argentina Bahiagrass (V2) and Bermudagrass (V3) at 204.8 and 140.6 µmol/g respectively. The results also showed a significant increase in the average of proline leaves content by increasing salinity levels. The highest average was 270.7 µmol/g at the treatment of 5 dS/m (S2), while the lowest average was 167.2 µmol/g in control treatment (S1), with an increase of 61.9%. While there was no significant difference between the leaves in the content of proline when treated with potassium, the control treatment (K0) exceeded the recommended treatment (K1) by the value 233.7 µmol/g and 204.9 µmol/g for both of them respectively.The results in the same table refer to significant effect of the interaction between varieties (V) and levels of salt treatments (S), the V1S2 interaction treatment gave the highest mean of 509.0 µmol/g, followed by interaction treatment V1S4 with a value of 361.0 µmol/g .The rest of the other interactions were less, but there were no significant differences between them. The interaction between the addition of saline concentrations (S) and potassium treatment (K) was differed significantly, which the highest value was observed in the interaction treatments S4K0 (294.1µmol/g) and S3K1 (294.9 µmol/g), while the lowest value appeared in the S2K1 treatment (141.4 µmol/g).

The results also showed a significant difference between the interaction treatment varieties and Potassium application (VK), V1K0 and V1K1 interaction treatments are superior to other treatments by the value of 321.2 µmol/g and 303.5 µmol/g, while the V3K1 interaction treatment has a least value by the rate of 109.1 µmol/g. With regard to triple interaction among the study factors VSK , results showed in the same table that was a significant differences , where the interaction treatment of V1S2K1 exceeds the rest of the other treatments with an average of 620 µmol/g, this value was reduced to lowest value of(55.8 µmol/g in the interaction treatment V1S1K0. The reason for increasing the content of the leaves of the proline by increasing the salinity of irrigation water regarded to the speed of its construction and low use as well as the inhibition of the oxidizing enzymes of proline. The increase in proline accumulation is also due to the increased destruction of proteins and their transformation into amino acids, including proline, where this amino acid works to regulate the osmosis of plant tissue cells and reduce the ionic effect resulting from salt stress, where proline leads to reorganization of osmosis of the plant to be able to overcome osmosis for soil solution and contributes to the restriction of toxic elements absorbed under saline conditions (Ashraf and Foolad, 2007).

**Table 1 Effect of varieties, salinity treatment levels, Potassium and interactions between them on Proline (µmol/g).**

| Potassium (K) | Salinity treatment (S) | Variety (V) | | | S×K |
|---|---|---|---|---|---|
| | | V1 | V2 | V3 | |
| K0 | S1 | 55.8 g | 234.8 cdefg | 176.1 defg | 155.6 bc |
| | S2 | 398.0 bc | 250.7 cde | 93.1 efg | 178.8 bc |
| | S3 | 324.8 cd | 151.6 defg | 234.7 cdefg | 247.2 ab |
| | S4 | 506.5 ab | 193.6 defg | 184.7 defg | 294.1 a |
| K1 | S1 | 251.4 cde | 218.5 defg | 66.5 fg | 237.0 abc |
| | S2 | 620.0 a | 143.6 defg | 118.8 efg | 141.4 c |
| | S3 | 127.0 efg | 204.7 defg | 92.7 efg | 294.9 a |
| | S4 | 215.6 defg | 241.3 cdef | 158.5 defg | 205.1 abc |
| | | | | | **K** |
| V×K | K0 | 321.2 a | 207.7 b | 172.1 bc | 233.7 a |
| | K1 | 303.5 a | 202.0 b | 109.1 c | 204.9 a |
| | | | | | **S** |
| V×S | S1 | 153.6 c | 226.6 c | 121.3 c | 167.2 c |
| | S2 | 509.0 a | 197.1 c | 105.9 c | 270.7 a |
| | S3 | 225.9 c | 178.2 c | 163.7 c | 189.2 bc |
| | S4 | 361.0 b | 217.4 c | 171.6 c | 250.0 ab |
| V | | 312.3 a | 204.8 b | 140.6 c | |

**Means accompanied by the same small letter in the same column are not significantly different at the P = 0.05**

## Leaves content of Potassium (%):

The results in Table (2) show That there are significant differences in Potassium leaves content among the varieties (V) , where it reached the highest average of Potassium in Argentina Bahiagrass variety (V2) and Tall fescue variety V1 at an average of 1.00 and 0.94% respectively, followed by the Bermudagrass V3 which differed significantly by the rate of

0.77%, while there was no significant difference between the leaves in the content of Potassium when treated with different levels of salt concentration, the control treatment (S1)and 15 dS/m (S4) treatment which reached 0.95% K exceeded 5 and 10 dS/m treatments which reached the value 0.90 and 0.83% respectively. The results also showed that the Potassium application does not have significant effect on the content of the leaves of potassium, despite the superiority of the recommended treatment K1 on a control treatment (K0) with a value of 0.95 and 0.86% for each of them. The results in the same table refer to significant effect of the interaction between varieties (V) and levels of salt treatments (S), the V1S1 interaction treatment gave the highest average of 1.24 %, while least value occurred in V1S4 treatment, which reached 0.55 %. The interaction between the addition of saline concentrations (S) and potassium treatment (K) did not differed significantly, which the highest value was observed in the interaction treatments S4K1 (1.03%), but the least value occurred in S1K1 interaction treatment (0.75%). The results also showed a significant difference between the interaction treatment varieties and Potassium application VK, V2K1 interaction treatment is superior to other treatments by the value of 1.19%, while the V3K0 has a least value by the rate of 0.76%. With regard to triple interaction among the study factors VSK, results showed in the same table that was a significant differences, where the interaction treatment of V1S1K0 and V2S4K1 exceeds the rest of the other treatments with an average of 1.49 and 1.47 % this value was reduced to lowest value of0.48 and 0.57% in the interaction treatment V1S4K0 and V3S3K0. Potassium is an important component of a turfgrass fertility program. Although effects from $K^+$ application may not be readily evidenced through increased turf shoot growth or darker green leaf colour, $K^+$ can reduce numerous stresses on turf. One of the primary ways that $K^+$ reduces turf stress is through regulation of stomatal functioning, which enhances shoot water potential of the turfgrass plant. Maintenance of turgor potential by $K^+$ can also help overcome stress effects of salinity. Turfgrass wear tolerance increases with increasing potassium nutrition (Trenholm *et al*., 2001). Salt-stressed root growth has restricted by osmotic effects and toxic effects of ions, which results in lower nutrient uptake and inhibits the translocation of mineral nutrients, especially $K^+$ (Shabala and Pottosin, 2010; Shabala and Cuin, 2008). Uddin et al, (2012) demonstrated that, as salinity increased, plant $K^+$ levels decrease and to a lesser degree, there is a decrease in Ca, Mg, and P. $K^+$ deficiency had usually be observed under salinity stress. An increasing $K^+$ supply corresponded with higher $K^+$ accumulation in plant tissue, which reduced the $Na^+$ concentration and resulted in a higher $K^+/Na^+$ ratio. The addition of $K^+$ to a saline culture solution has been found to increase $K^+$ concentrations in plant tissue that corresponds with a decrease in $Na^+$ content, with a further increase in plant growth and salt tolerance. Increased evidence shows that it is not the absolute quantity of $Na^+$ perse that influences salt resistance, but rather the cytosolic $K^+/Na^+$ ratio that determines plant salt tolerance (Shabala, Pottosin, 2010 ; Shabala and Cuin, 2008).

**Leaves content of Sodium (%):**

The results in Table (3) show a significant differences in sodium leaves content among the varieties (V), where Tall fescue variety (V1) reached the highest average of Sodium by 0.52% and exceeded Argentina Bahiagrass (V2) and Bermudagrass (V3) which reached 0.46 and 0.30 % respectively. The results also showed a significant increase in the average of Sodium leaves content by increasing salinity levels. The highest average was 0.75% at the treatment of 10 dS/m (S3), while the lowest average was 0.16% in control treatment (S1), with an increase of 368.75 %. While there was no significant difference between the leaves in the content of Sodium when treated with potassium, but the recommended treatment (K1) exceeded the control treatment (K0) by the value 0.44 and 0.41% for both of them respectively. The results in the same table refer to significant effect of the interaction between varieties (V) and levels of salt treatments (S), the V1S3 interaction treatment gave the highest average of 0.96%, followed by the least interaction treatment V3S1 with a value of 0.12%.

**Table 2 Effect of varieties, salinity treatment levels, Potassium and interactions between them on potassium content (K %)**

| Potassium (K) | Salinity treatment (S) | Variety (V) | | | S×K |
|---|---|---|---|---|---|
| | | V1 | V2 | V3 | |
| K0 | S1 | 1.49 a | 0.75 bcde | 0.64 cde | 0.96 a |
| | S2 | 1.28 ab | 0.71 cde | 0.65 cde | 0.94 a |
| | S3 | 0.83 bcde | 0.85 bcde | 0.57 e | 0.88 a |
| | S4 | 0.48 e | 0.97 abcde | 1.17 abc | 0.92 a |
| K1 | S1 | 0.99 abcde | 1.12 Abcd | 0.71 cde | 0.75 a |
| | S2 | 0.86 bcde | 1.25 ab | 0.66 cde | 0.91 a |
| | S3 | 1.00 abcde | 0.94 bcde | 0.81 bcde | 0.87 a |
| | S4 | 0.62 de | 1.47 a | 1.00 abcde | 1.03 a |
| | | | | | **K** |
| **V×K** | **K0** | 1.02 ab | 0.82 bc | 0.76 c | 0.86 a |
| | **K1** | 0.87 bc | 1.19 a | 0.79 bc | 0.95 a |
| | | | | | **S** |
| **V×S** | **S1** | 1.24 a | 0.93 ab | 0.67 bc | 0.95 a |
| | **S2** | 1.07 a | 0.98 ab | 0.65 bc | 0.90 a |
| | **S3** | 0.91 ab | 0.89 abc | 0.69 bc | 0.83 a |
| | **S4** | 0.55 c | 1.22 a | 1.08 a | 0.95 a |
| **V** | | 0.94 a | 1.00 a | 0.77 b | |

**Means accompanied by the same small letter in the same column are not significantly different at the P = 0.05**

The interaction between the addition of saline concentrations (S) and potassium treatment (K) was also differed significantly, which the highest value was observed in the interaction treatments S3K1 (0.92%) while the lowest value appeared in the S1K0 and S2K0 treatment (0.15 and 0.17%). The results also showed a significant difference between the interaction treatment of varieties and Potassium application (VK), V1K1 interaction treatment is superior to other treatments by the value of 0.66 %, while the V3K1 interaction treatment has a least value by the rate of 0.20 %. With regard to triple interaction among the study factors VSK, results registered in the same table that was a significant difference, where the interaction treatment of V1S3K1 exceeds the rest of the other treatments with an average of 1.48%, this value was reduced to 0.09, 0.11, 0.13, 0.14, 0.14, 0.16 and 0.18% respectively in the interaction treatments V1S1K1, V3S1K0, V3S1K1, V1S2K1, V3S4K1, V2S1K0 and V2S4K1 respectively. The increase in sodium levels by increasing salinity of irrigation water may be due to that absorbed $Na^+$, which free through diffusion, is to be released by active pumping, so it is easy to enter into the plant and then accumulate in the leaves, these results are agree with (Khalil *et al*., 2011; Roussos *et al*., 2013 and Khoshbakht *et al.*, 2014).

**Table 3 Effect of varieties, salinity treatment levels, Potassium and interactions between them on sodium content (Na %).**

| Potassium (K) | Salinity treatment (S) | Variety (V) | | | S×K |
|---|---|---|---|---|---|
| | | V1 | V2 | V3 | |
| K0 | S1 | 0.19 fg | 0.16 g | 0.11 g | 0.15 d |
| | S2 | 0.34 defg | 0.21 fg | 0.37 defg | 0.17 d |
| | S3 | 0.44 defg | 0.79 cd | 0.53 cdef | 0.31 cd |
| | S4 | 0.58 cde | 0.63 cd | 0.59 cde | 0.27 cd |
| K1 | S1 | 0.09 g | 0.30 defg | 0.13 g | 0.59 b |
| | S2 | 0.14 g | 0.41 defg | 0.25 efg | 0.60 b |
| | S3 | 1.48 a | 0.99 b | 0.29 defg | 0.92 a |
| | S4 | 0.95 b | 0.18 g | 0.14 g | 0.42 bc |
| | | | | | K |
| V×K | K0 | 0.39 b | 0.45 b | 0.40 b | 0.41 a |
| | K1 | 0.66 a | 0.47 b | 0.20 c | 0.44 a |
| | | | | | S |
| V×S | S1 | 0.14 cd | 0.23 bcd | 0.12 d | 0.16 d |
| | S2 | 0.24 bcd | 0.31 bcd | 0.31 bcd | 0.29 c |
| | S3 | 0.96 a | 0.89 a | 0.41 b | 0.75 a |
| | S4 | 0.76 a | 0.40 b | 0.36 bc | 0.51 b |
| V | | 0.52 a | 0.46 b | 0.30 b | |

**Means accompanied by the same small letter in the same column are not significantly different at the P = 0.05**

## Total chlorophyll (a+b) in leaves (mg/g):

The results in Table (4) show That there are significant differences among the varieties (V) in total chlorophyll content in leaves, where Tall fescue variety (V1) reached the highest average by 4.27 mg/g , followed by the Bermudagrass (V3) and Argentina Bahiagrass(V2) In which chlorophyll content was reported 3.33 and 2.02 mg/g respectively. While there was no significant difference between the leaves content of chlorophyll when treated with different levels of salt concentration. As well, no significant difference between Potassium applications levels (K0 and K1) where the results were very close between the four levels of salt treatments on the one hand and between K applications on the other. The results in the same table refer to significant effect of the interaction between varieties (V) and levels of salt treatments (S), the V1S3 interaction treatment gave the highest average of 5.29 mg/g, followed by interaction treatment V2S4 with a value of 1.77 mg/g, which reached the least value. As well the results showed no significant difference between the leaves content of chlorophyll when treated with different levels of salt concentration and Potassium (SK), But there were significant differences in case of interaction between varieties and Potassium application, highest value occurred in V1K0( 4.47mg/g) and lowest in V2K0 and V2K1 (1.92 and 2.12 mg/g) respectively. The results from the same table also showed a significant differences among three factors used (VSK), where the interaction treatment of V1S3K1 exceeds the rest of the other treatments with an average of 5.56mg/g , this value was reduced to lowest value of 1.48 mg/g in the interaction treatment V2S4K0.

It was observed that the chlorophyll content varied according to types of variety but saline additives have no apparent effect on chlorophyll content. A new generation of salt-tolerant turf varieties might allow landscape development in saline environments and might be ideal in such environments where salt water spray is a problem, or where limited or no fresh water is available for irrigation (Hester *et al*., 2001; Gulzar *et al*., 2003). There are a number of potential turfgrass species that may be appropriate at various salinity levels (Murdoch, 1987). During the onset and development of salinity stress within a plant, all the major processes, including photosynthesis, protein synthesis, as well as energy and lipid metabolism, are affected (Parida and Das, 2005). Plants experience water stress during the initial exposure of salt, followed by leaf expansion reduction (Carillo *et al*., 2011).

**Table 4 Effect of varieties, salinity treatment levels, Potassium and interactions between them on total chlorophyll (a+b) (mg/g).**

| Potassium (K) | Salinity treatment (S) | Variety (V) | | | S×K |
|---|---|---|---|---|---|
| | | V1 | V2 | V3 | |
| K0 | S1 | 4.30 abcd | 1.90 fg | 2.83 cdefg | 3.01 a |
| | S2 | 4.10 abcde | 2.05 efg | 3.15 bcdefg | 3.34 a |
| | S3 | 5.02 ab | 2.24 defg | 3.22 bcdefg | 3.10 a |
| | S4 | 4.45 abc | 1.48 G | 3.65 abcdef | 3.04 a |
| K1 | S1 | 3.94 abcdef | 2.02 fg | 4.06 abcde | 3.49 a |
| | S2 | 3.33 bcdefg | 2.24 defg | 3.54 abcdefg | 3.43 a |
| | S3 | 5.56 a | 2.16 efg | 2.57 cdefg | 3.19 a |
| | S4 | 3.48 bcdefg | 2.06 efg | 3.64 abcdef | 3.06 a |
| | | | | | **K** |
| V×K | K0 | 4.47 a | 1.92 c | 3.21 b | 3.20 a |
| | K1 | 4.08 ab | 2.12 c | 3.45 b | 3.21 a |
| | | | | | **S** |
| V×S | S1 | 4.12 ab | 1.96 d | 3.44 bc | 3.17 a |
| | S2 | 3.72 b | 2.14 cd | 3.34 bc | 3.07 a |
| | S3 | 5.29 a | 2.20 cd | 2.89 bcd | 3.46 a |
| | S4 | 3.96 b | 1.77 d | 3.64 b | 3.12 a |
| V | | 4.27 a | 2.02 c | 3.33 b | |

**Means accompanied by the same small letter in the same column are not significantly different at the P = 0.05**

## References


1. Ahmed, M.R. and R. Hassan, 2003. People's perception toward value of urban green space in environmental development. Congress papers of the World Forest Congress, Quebec Canada, PP: 21-28 September.
2. Arnon, D.I. 1949. Copper enzymes in isolated chloroplasts polyphenoloxidase. Beta vulgaris, Plant Physiology, 24(1): 1-15.
3. Ashraf, M. and M.R. Foolad, 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. Environmental and experimental botany, 59(2): 206-216.
4. Ashraf, M; H.R. Athar; P.J.C. Harris, and T.R. Kwon, 2008. Some prospective strategies for improving crop salt tolerance. Advances in Agronomy, 97: 45–110.

5. Bates, L.S; R.P. Waldren, and I.D. Teare, 1973. Rapid determination of free proline for water-stress studies, Plant and Soil, 39(1): 205-207.
6. Borchardt, W. 1999. Pflanzenverwendung im Garten und Landschaft. 2. korrigierte Auflage, Eugen Ulmer Verlag, Hohenheim Stuttgart, 140. C4 turfgrass. J. Am. Soc. Hort. Sci, 119(4): 779-784.
7. Carillo, P; M.G. Annunziata; G. Pontecorvo; A. Fuggi, and P. Woodrow, 2011. Salinity stress and salt tolerance. *In* A. Shanker and B. Venkateswarlu (eds.), Abiotic Stress in Plants - Mechanisms and Adaptations. InTech. doi: 10.5772/22331.
8. Flowers, T.J. 2004. Improving crop salt tolerance. *Journal of Experimental Botany*, 55 (396): 307-319.
9. Gulzar, S; M.A. Khan, and IA. Ungar, 2003. Salt tolerance of a coastal salt marsh grass. Communications in Soil Science and Plant Analysis. 34(17-18): 2595–2605.
10. Harivandi, A; J.D. Bulter, and L. Wu 1992. Salinity and turfgrass culture. In: Waddington DV, editor. Turfgrass Agronomy Monograph. Madison, Wis, USA: ASA. CSSA and SSSA, 208–230.
11. Hasegawa, P.M; R.A. Bressan; J.K. Zhu, and H.J. Bohnert, 2000. Plant cellular and molecular responses to high salinity. Ann. Rev. of Plant Physiol, 51: 463–499.
12. Hester, M.W; I.A. Mendelssohn, and K.L. McKee, 2001. Species and population variation to salinity stress in Panicum hemitomon, Spartina patens, and Spartina alterniflora: morphological and physiological constraints. Environmental and Experimental Botany. 46(3): 277–297.
13. Jacoby, B. 1999. Mechanism involved in salt tolerance of plants. In: Pessarakli M, editor. Handbook of Plant and Crop Stress. New York, NY, USA: Marcel Dekker, 97–124.
14. Khalil, H.A; A.M. Eissa; S.M. El-Shazly, and A.M.A. Nasr, 2011. Improved growth of salinity-stressed citrus after inoculation with mycorrhizal fungi. Scientia horticulturae, 130(3): 624-632.
15. Khoshbakht, D; A.A. Ramin, and B. Baninasab, 2014. Citrus Rootstocks Response to Salinity: Physio-biochemical Parameters Changes. Res. J. Environ. Sci, 8(1): 29-38.
16. Marcum, K.B. 2006. Use of Saline and Non-potable Water in the Turfgrass Industry: Constraints and Developments. Agril. Water Manage, 80(1-3): 132-146.
17. Munns, R. 2002. Comparative physiology of salt and water stress. Plant Cell Environ, 25(2): 239-250.
18. Munshaw, W.G; E. Ervin, and X. Zhang, 2004. Pass the salt. Golf Course Management, 81–92.
19. Parida, A.K. and A.B. Das, 2005. Salt tolerance and salinity effects on plants: A review. Ecotox. Environ. Safe, 60: 324–349.
20. Piperno, D.R. and H-D. Sues, 2005. Dinosaurs dined on grass. Science, 310(5751): 1126–1128.
21. Prasad, V; C.A.E. Strömberg; H. Alimohammadian, and A. Sahni, 2005. Paleontology: dinosaur coprolites and the early evolution of grasses and grazers. Science, 310(5751): 1177–1180.
22. Roussos, P.A; D. Gaspartos; C. Kyriakou; K. Tsichli; E. Tsantili, and C. Haidouti, 2013. Groth, Nutrient Status, and Biochemical Changes of Sour orang Plants Subjected to Sodium Chloride Stress. Soil Science and Plant Analysis, 44:805-816.
23. Shabala, S. and I.I. Pottosin, 2010. Potassium and potassium-permeable channels in plant salt tolerance. Signal. Commun. Plants, 87–110.
24. Shabala, S. and T.A. Cuin, 2008. Potassium transport and plant salt tolerance. Physiol. Plantarum, 133: 651–669.
25. Tapia Silva, O.F. 2002: Rechner-, modell- und messwertgestützte Untersuchungen in urbanen Teilräumen Berlins zur Verdunstungsmodellierung unter Berücksichtigung von Gleisbett-Naturierungen. Fortschritt-Berichte VDI Verl. Dissertation,Berlin. Turfgrass Industry: Constraints and Developments. Agril. Water Turfgrass Soc. Res. J, 8: 735-742.

26. Trenholm, L.E; R.N. Carrow, and R.R. Duncan, 2001. Potassium for Enhancement of Turfgrass Wear Tolerance. Better Crops, 85(2): 14-17.
27. Uddin, M.K; A.S. Juraimi; M.R Ismail; U.A. Naher; R. Othman, and A.A. Rahim, 2011. Application of saline water and herbicides as a method for weed control in the tropical turfgrass: its impact on nutrient uptake and soil microbial community. African Journal of Microbiology Research, 5(29): 5155–5164.
28. Uddin, M.K; A.S. Juraimi; M.R. Ismail; M.A. Hossain, and M.A. Alam, 2012. Effect of salt stress of Portulaca oleraceaon antioxidant properties and mineral compositions. Australian Journal of Crop Science, 6: 1732–1736.
29. Yang, Y.; Q. Zheng; M. Liu; X. Long; Z. Liu; Q. Shen, and S. Guo 2012. Difference in sodium spatial distribution in the shoot of two canola cultivars under saline stress. Plant Cell Physiol, 53(6): 1083–1092.