Effect of Salinity and Drought Stress on the Seedling Growth and Physiological Traits of Vetiver Grass (*Vetiveria zizanioides* stapf.)

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**ABSTRACT** Vetiver grass is known to survive under diverse soil and water conditions. In order to test its potential of salinity and aridity tolerance ability, the effect of salinity and aridity stress on the growth of the *Vetiveria zizanioides* was studied by growing plants in arid soils that receiving salinity stress. The experiment was conducted in a greenhouse, arrangement in a completely randomized design using 5 replications. Salinity levels of 4 (as control), 20, 30 and 40 dS m⁻¹; Aridity levels of field capacity irrigation (as control), -6 and -10 bars were applied. There was no significant effect on growth, yield, water content and chlorophyll concentration with 20 dS m⁻¹ salinity level. There was significant effect on mentioned parameters with 30 and 40 dS m⁻¹ salinity levels. The root and length weight in -6 bar were significantly greater than those in control. The water content and chlorophyll concentration were highest in 40 dS m⁻¹ and -10 bars salinity-aridity. Water content and chlorophyll concentration were lowest in 4 dS m⁻¹ and FC salinity-aridity treatments. Our results suggest that in EC between 20 to 30 dS m⁻¹ with -6 to -10 bars water content *Vetiveria zizanioides* could be used for soil rehabilitation.

**Key words:** Halophytes, Rangelands, Saline, Xerophytes

1 **INTRODUCTION**

Soils with electrical conductivity (EC) more than 2 dS m⁻¹ are considered saline (Alizadeh, 1999). The plants that can be naturally established in saline soils are called halophytes (Tabaee Oghdaee, 1999). The plants that can be naturally established in drought soils are called xerophytes (Richards, 1954). Salinity and aridity stresses cause reduced in nutrient uptake by roots and eventually plant death (Jafari, 1994). Thus, soil salinity and aridity stresses can reduce plant production potential (Kafi and Mahdavi, 2012).

Salinity and drought have considerable adverse impacts on productivity of plants (Lauchli and Epstein, 1990). These adversely affect plant growth and development. An excess of soluble salts in the soil leads to osmotic stress, specific ion toxicity and ionic imbalances (Munns, 2003) and the consequences of these can be plant death or production losses in plants (Rout and Shaw, 2001). Ashraf et al. (2004) found that increasing salt concentrations caused a significant reduction in the fresh and dry masses of in plants. Limited water supply is also another major environmental constraint in productivity of plants. Moisture deficiency induces various physiological and metabolic responses like stomatal closure and decline in
growth rate and photosynthesis (Flexas and Medrano, 2002). The results of Baher et al. (2002) showed that greater soil water stress decreased plant height and total fresh and dry weight of plants. Colom and Vazzana (2002) also showed that the number of stem per plant and plant dry weight were negatively related to water stress in plants.

Vetiver grass provides vegetative cover in situations where other vegetation is unable to establish due to extremes of salinity and aridity soils (Loch, 2006). The saline threshold of vetiver grass is EC = 8 dS m\(^{-1}\) and soil EC values of 10 and 20 dS m\(^{-1}\) would reduce its yield by 10% and 50% respectively (Truong et al., 2002). Vetiver grass can grow in the salinity ranged from 1-10 dS m\(^{-1}\) (Patcharee and MongKon, 2001; Cook, 1993; Chaweevan et al., 1996; Nanakorn et al., 1996).

So vetiver grass establishment and growth were extremely poor under the extremely saline conditions (Truong et al., 2002). Its root went down to 70cm and penetrating the saline soil and reaching sub surface moisture which the other plant can not do and dissolved salt content were greatly reduced (Du and Truong, 2000). Vetiver grass has short rhizomes and massive finely structured root systems that grow very quickly. It has been reported that its root to grow 1 meter in the first year (Truong et al., 2002). This deep root system makes the vetiver plant extreme drought tolerant. So vetiver grass can establish in arid areas that receive less than 200 mm of rain a year so it has a high aridity tolerance (Fraser, 1993). Vetiver grass is well known as being a drought and salt tolerant plant (Vimala and Kataria, 2005).

Salinity reduces the ability of plants to take up water, and this causes reductions in growth rate along with a suite of metabolic changes similar to those caused by water stress. Hence, the ability of a plant to grow under these environmental stress conditions is a key factor to improve rangeland vegetation in saline and arid rangelands (Sharp and Davies, 1979; Sharp and Davies, 1985; Netting, 2000; Bruce et al., 2002). So salinity and aridity alter plant growth rate and nutrient uptake (Sharp and Davies, 1979; Sharp and Davies, 1985; Netting, 2000; Bruce et al., 2002). Salinity and aridity tolerance ability of *Vetiveria zizanioides* were the objects of this study.

## 2 MATERIAL AND METHODS

The Scions of *Vetiveria zizanioides* were taken from Research Institute of Forests and Rangelands. Plants were grown in Malayer University greenhouse at 15-40°C under a photoperiod of 16 h. Scions were planted in pots of 14 cm diameter and 25 cm depth; each pot contained 3.5 kg soil. The soil characteristics were as follows: Entisol in type, sandy clay loam in texture, sand 53.7%; silt 7.14%; clay 39.16%; pH 9.63 and organic matter 0.87%.

Salinity levels of 20, 30, and 40 dS m\(^{-1}\) as different levels of salinity treatments and salinity level of 4 dS m\(^{-1}\) as control were applied on the pots. Sodium chloride (NaCl) was used to make salinity treatments. Adds 0.64 gr of NaCl per 1 kg soil increased one grade salinity level (in term of dS m\(^{-1}\)). Pots used in this study are 3.5 Kg. So weight of salt needed at each salinity level to be calculated (Kachout et al., 2009). The salinity treatments at 4 levels [4 (control), 20, 30, and 40 dS m\(^{-1}\)] were made with this method.

3 levels of aridity levels were implemented on pots with Pressure plates. Aridity levels of field capacity irrigation (as control), -12 and -14 bars were applied. Each pot was weighed every 3 days.

The decreased weight of each pot in each round of review showed the amount of water evaporated or consumed by the plants. So this weight of water was added to pots by irrigation water (Alizadeh, 1999). The plant height (cm), root system length (cm) and leaf area (cm\(^2\)) were measured (after 3 months). Plants were washed with distilled water and separated into shoots and roots. The dry weight (dw) was obtained after oven drying the plants at 60 °C for 48 hours. The dry weights of the root and shoot systems were also determined. The effect of salinity on
physiology parameters was studied in terms of water content and chlorophyll concentration.

Chlorophyll concentration were estimated spectrophotometrically (Metzner et al., 1965), after acetone extraction of the pigments from fresh leaves. Chlorophyll concentration was determined with three replicate plants. A leaf sample of 0.1 g was ground and extracted with 5 mL of 80% (v/v) acetone in the dark. The slurry was filtered and absorbancies determined at 645 and 663 nm (Kachout et al., 2009). The pot experiment was set up in a completely randomized design using 5 replications. ANOVA was employed for statistical analysis of data. Statistical significance was defined as P < 0.05 (Kachout et al., 2009).

3 RESULTS

Effect of salinity on dry weight and growth, leaf growth, chlorophyll concentration and water content

Salt stress significantly affected leaf area in vetiver. The highest leaf area values occurred in the lowest salinity level (4 dS m\(^{-1}\)). Compared to the 4 dS m\(^{-1}\) treatment, leaf area was reduced by 28.32%, 38.22 % and 47.26 % in the 20, 30, and 40 dS m\(^{-1}\) salt treatments, respectively. There was no significant effect on leaf area with 20 dS m\(^{-1}\) salinity level. But there was significant reduction in leaf area with 30 and 40 dS m\(^{-1}\) salinity level.

Shoot height, shoot dry weight, root length and root weight at all stages of development were reduced progressively with increasing salinity concentrations. The relative percentage of the shoot height, shoot dry weight, root length, and root weight of the salinized plants compared to those of the controls were computed as (salinized plants/control plants) x100 and illustrated in (Figure 1).

Figure 1 Relative percentage of the shoot height, shoot dry weight, root length, and root weight of salinized plants compared to those of the controls. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD) (A: shoot height, B: shoot weight, C: root length and D: root weight)
Changes in leaf chlorophyll concentration under different salinity stresses levels are shown in Figure 2. The concentrations of chlorophyll were highest in the 40 dS m\(^{-1}\) salinity treatment and lowest in 4 dS m\(^{-1}\) salinity treatment.

The water content of leaves of vetiver was highest in plants grown at 4 dS m\(^{-1}\), followed by the leaves grown at 20 and 30 dS m\(^{-1}\) and the lowest water content was in 40 dS m\(^{-1}\). So soil salinity increased due to water content reduction in vetiver. (Figure 3).

**Effect of aridity on dry weight and growth, leaf growth, chlorophyll concentration and water content**

Leaf area declined significantly along decreasing soil moisture. The highest leaf area values were in lowest aridity (FC) level. Compared to the FC treatment, leaf area was reduced by 48.52 % and 73.13 % in the -6 and -10 bar aridity treatments, respectively. So there was significant effect of aridity on leaf area in vetiver.

Shoot dry weight at all stages of development was reduced progressively with increasing drought level.

Soil drought enhancement significantly retarded (p < 0.05) dry weight of stems (Figure 4). Dry weight significantly decreased (p< 0.05) for shoots and total biomass of plants in response to increasing drought level (Figure 4). Root height and root dry weight were highest in -6 bar aridity level (Figure 4). The relative percentage of the shoot height, shoot dry weight, root length, and root weight of the under drought stress plants compared to those of the controls were computed as (salinized plants/control plants) x100 and illustrated in Figure 4.

Values of percentage relative varied from 100, 32 and 17 % for shoots height, from 100, 28 and 21 % for shoot weight, from 97, 100 and 53% for root height and from 95, 100 and 32 % for root weight to increasing soil aridity from FC to -6 and -10 bars. In experiment, dry plant weight decreased dramatically with the increasing NaCl concentration. The greatest dry plant weight of vetiver was obtained with the first treatment in all range of drought treatments. The general tendency was that increasing concentrations of salt induced a progressive decline in the length of shoots and in the weight of roots, stems and leaves.
Effect of salinity and Drought Stress on Vetiver Grass


Figure 4 Effect of aridity on root and shoot dry weights of *Vetiveria zizanioides*. Different letters represent a significant difference (P<0.05) between treatments. (A: shoot height, B: shoot weight, C: root length and D: root weight)

With increasing in aridity level from FC to -10 bars resulted in significantly progressive decline of photosynthetic pigment. Leaf chlorophyll concentration was reduced from 48 to 27 and 16 %, for FC, -6 and -10 bars aridity level (Figure 5).

Aridity stress significantly decreased water content of leaves from 7% in control treatment to 5% and 4% at -6 to -10 aridity level (Figure 6).

**Effect of Salinity×aridity interaction on dry weight and growth, leaf growth, chlorophyll concentration and water content**

The application of Salinity and aridity combination stress significantly affected plant growth factors of vetiver (Table 1). Leaf Area, shoot height, shoot weight, root height, root weight, chlorophyll concentration and water content of vetiver were significantly affected by salinity and aridity combination stress. Leaf area and water content of vetiver were significantly reduced under the stress more than the non-stressed plants (Table 1). Maximum reduction was found in -6 bars×40 dS m⁻¹ and -10 bars×40 dS m⁻¹ treatments compared to non-stressed plants.
**Figure 5** Effects of various aridity levels on chlorophyll concentration. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD).

**Figure 6** Effects of various aridity levels on leaves water content. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD).

**Table 1** Effect of salinity on leaf area (cm²), root and shoot height (cm) and dry weights (g), chlorophyll concentration (mg g⁻¹ FW) and water content (%) of Vetiveria zizanioides. Different letters represent a significant difference (P<0.05) between treatments.

<table>
<thead>
<tr>
<th>Salinity</th>
<th>Leaf Area</th>
<th>Shoot Height</th>
<th>Shoot Weight</th>
<th>Root Height</th>
<th>Root Weight</th>
<th>Chlorophyll Concentration</th>
<th>Water Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC×4 dS m⁻¹</td>
<td>5.8 a</td>
<td>0.42 a</td>
<td>0.44 a</td>
<td>0.31 a</td>
<td>0.43 a</td>
<td>0.43 c</td>
<td>0.78 a</td>
</tr>
<tr>
<td>-6 bars×4 dS m⁻¹</td>
<td>4.2 b</td>
<td>0.40 a</td>
<td>0.35 b</td>
<td>0.32 a</td>
<td>0.45 a</td>
<td>0.45 c</td>
<td>0.53 b</td>
</tr>
<tr>
<td>-10 bars×4 dS m⁻¹</td>
<td>3.2 c</td>
<td>0.27 bc</td>
<td>0.16 c</td>
<td>0.14 c</td>
<td>0.19 c</td>
<td>0.11 d</td>
<td>0.43 cd</td>
</tr>
<tr>
<td>FC×20 dS m⁻¹</td>
<td>3.3 c</td>
<td>0.40 a</td>
<td>0.34 b</td>
<td>0.27 b</td>
<td>0.28 b</td>
<td>0.47 bc</td>
<td>0.52 b</td>
</tr>
<tr>
<td>-6 bars×20 dS m⁻¹</td>
<td>2.1 d</td>
<td>0.32 b</td>
<td>0.18 c</td>
<td>0.28 b</td>
<td>0.32 b</td>
<td>0.51 ab</td>
<td>0.38 d</td>
</tr>
<tr>
<td>-10 bars×20 dS m⁻¹</td>
<td>1.7de</td>
<td>0.21 c</td>
<td>0.11 c</td>
<td>0.16 c</td>
<td>0.11 d</td>
<td>0.13 d</td>
<td>0.21 e</td>
</tr>
<tr>
<td>FC×30 dS m⁻¹</td>
<td>2 d</td>
<td>0.14 d</td>
<td>0.06 e</td>
<td>0.07 e</td>
<td>0.04 ef</td>
<td>0.49 b</td>
<td>0.36 d</td>
</tr>
<tr>
<td>-6 bars×30 dS m⁻¹</td>
<td>1.1 f</td>
<td>0.08 e</td>
<td>0.01 ef</td>
<td>0.09 ef</td>
<td>0.06 ef</td>
<td>0.52 a</td>
<td>0.14 f</td>
</tr>
<tr>
<td>-10 bars×30 dS m⁻¹</td>
<td>0 g</td>
<td>0.01 f</td>
<td>0.1 ef</td>
<td>0.03 f</td>
<td>0.02 f</td>
<td>0.08 ef</td>
<td>0.08 gh</td>
</tr>
<tr>
<td>FC×40 dS m⁻¹</td>
<td>1.8 de</td>
<td>0.11 de</td>
<td>0.01 ef</td>
<td>0.05 ef</td>
<td>0.04 ef</td>
<td>0.51 ab</td>
<td>0.06 gh</td>
</tr>
<tr>
<td>-6 bars×40 dS m⁻¹</td>
<td>0 g</td>
<td>0 f</td>
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<td>0 f</td>
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<td>0 h</td>
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<tr>
<td>-10 bars×40 dS m⁻¹</td>
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<td>0 f</td>
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<td>0 h</td>
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</table>
Shoot height and shoot weight were high in non-stressed plants compared to stressed plants. However, root height, root weight and chlorophyll concentration were greatest in -6 bars × 4 dS m⁻¹ treatments.

4 DISCUSSION
Effect of salinity on dry weight and growth, leaf growth, chlorophyll concentration and water content

Effect of drought and salinity stress on plants growth; have been mainly done on agricultural plant species. There are a few studies on the tolerance of rangeland plants to salinity stress (Akhzari et al., 2012; Sepehry et al., 2012; Kafi and Mahdavi, 2012; Masoudi et al., 1997; Ashraf et al., 1986) and tolerance of rangeland plants to drought stress (Munns, 2003; Baher et al., 2002; Colom and Vazzana, 2002; Flexas and Medrano, 2002). Therefore, the rangeland halophytic plant species must be classified into various salinity and drought tolerance levels.

A primary response in salt stressed plants is a decrease in plant water potential, resulting in decreased water use efficiency, leading to the overall toxic damages and yield reduction (Chaum and Kirdmanee, 2009). Salt stress affects water status (Amirjani, 2010). Water relations and the ability to adjust osmotically are important determinants of the growth response (Munns, 2003). Salinity stress caused to the decreased leaf water potential and a reduction in relative leaf water content which resulted in loss of turgor, which in turn causes stomatal closure and limits dioxide carbon assimilation and reduced photosynthetic rate. The decrease in total glycinebetaine in high level of NaCl level may be related to the reduced tissue water content (Khan et al., 2000).

Our results showed vetiver cans tolerant to high soil salinity. These results are consistent with the previous studies (Loch, 2006; Vimala and Kataria, 2005; Truong et al., 2002; Patcharee and MongKon, 2001; Du and Truong, 2000; Chaweevan et al., 1996; Nanakorn et al., 1996; Cook 1993). This is probably due to the high widespread root system of this species. (Truong et al., 2002; Du and Truong 2000) These results indicate vetiver grass can be compared favorably with some most salt tolerant crop and pasture species grown in the world.

In our study vetiver exhibited different degrees of salt tolerance. Other researchers have not observed growing this species at these ranges of salinity stresses (Loch, 2006; Vimala and Kataria, 2005; Truong et al., 2002; Patcharee and MongKon, 2001; Du and Truong, 2000; Chaweevan et al., 1996; Nanakorn et al., 1996; Cook 1993).

The maximum length and weight of the roots and the shoots were seen in the lowest salinity level (4 dS m⁻¹). However, the minimum length and weight of the roots and the shoots were seen in the highest salinity level (40 dS m⁻¹). In other words, under salinity stress conditions, nutrient and water absorption by roots and shoot growth were reduced (Ashraf et al., 2004; Munns, 2003; Rout and Shaw, 2001; Lauchli and Epstein, 1990).

The concentrations of chlorophylls were highest in the 40 dS m⁻¹ salinity treatment and lowest in 4 dS m⁻¹ salinity treatment. So salinity stress Causeed increased chlorophyll concentration. These results are consistent with the previous studies of Jungai et al., (2011). Plant exposed to saline environment generally has a reduction in leaf area. In the present study, salinity reduced the leaf area and chlorophyll content as the salinity level increased with significant effect. Salt stress reduced the leaf growth rate by shortening the length of the leaf elongating zone and decreasing the growth intensity in its central and distal portions (Bernstein et al., 1993). Leaf growth inhibition by salinity must be expected to occur via an effect on this region (Lazof and Bernstein, 1998). NaCl stress decreased total chlorophyll
content of the plant by increasing the activity of the chlorophyll degrading enzyme: chlorophyllase (Rao and Rao, 1981), inducing the destruction of the chloroplast structure and the instability of pigment protein complexes (Sing and Dubey, 1995).

**Effect of aridity on dry weight and growth, leaf growth, chlorophyll concentration and water content**

Drought stress has a significant effect on growth and accumulation of organic matter in various parts of plants leaves by reducing the rate of photosynthesis (Rad et al., 2001). Results of this research showed leaf area declined significantly as aridity increased from FC to -6 and -10 bars. Compared to the 4 dS m⁻¹ treatment, leaf area was reduced by 48.52% and 73.13 % in the -6 and -10 bar, respectively. These variations are due to different soil moistures treatments. This feature increased significantly with decreasing soil moisture.

Results of this research showed that different aridity level had different effects on dry matter production in both shoots and roots. Many studies indicate that increasing in drought stress could decrease all plant dry weight (Omidi, 2010; Jongrungklang et al., 2008; Abdalla and El-Khoshiban, 2007; Hamada, 1996). These reductions were significantly seen in shoot height and shoot weight in different aridity level in vetiver (Figure 4). However, Kameli and Losel (1996) reported that drought stress may increase root weight and decrease shoot weight. The root height and root weight increment under -6 bars aridity level have been seen in vetiver. In other words, the plant can also produce enough roots at -6 bars of drought stress. More stress caused a reduction in root growth, water uptake, mineral deficit and finally stop the growth. However the root height and root weight increment in -6 bars were not significantly different with the control level (Figure 4). The absorption of nutrients from the soil depends on the availability of water to roots. It is reported that soil water deficit may reduce root growth and limit nutrient uptake by roots (Arndt et al., 2001). This significant reduction (compared with the control and -6 bars aridity levels) has been seen in -10 bars aridity level (Figure 4). Li and Wang (2003), Gazal and Kubiske (2004), Bargali and Tewari (2004) consider a high root to shoot ratio as a drought tolerant parameter. They have emphasized that the first and most common feature of plant growth is increasing of root to shoot ratio in arid regions.

The chlorophyll concentration has highest value in -6 bars aridity level. The lowest concentration of chlorophyll was in -10 bars aridity treatment (Figure 5). Chlorophyll content of plant under drought stress depends on stress rate and duration (Rensburg and Kruger, 1994; Kyparissis et al., 1995; Jagtap et al., 1998). Fotovat et al. (2007) found that by exerting severe drought stress on plant, chlorophyll content of leaf significantly decreased. With decreasing chlorophyll content due to the changing green color of the leaf into yellow, the reflectance of the incident radiation is increased (Schlemmer et al., 2005). It seems that this mechanism can protect photosynthetic system against stress (Ganji et al., 2012).

Water deficit can destroy the chlorophyll and prevent making it (Lessani and Mojtahedi, 2002). The decrease in chlorophyll under drought stress is mainly the result of damage to chloroplasts caused by active oxygen species (Smirnoff 1995). So it can be said that in -10 bars aridity treatment, leaves chlorophylls have been destroyed.

Lower drought stress causes reducing the leaf area. In fact, the plants by reducing the leaf surface under the stress conditions reduce the transpiration area to prevent the wasted water. Therefore, the chlorophyll content increases per unit of leaf area (Bohrani and Habili., 1992). It
The physiological responses of vetiver were investigated under drought and salt stress combination. The dry weight and growth of vetiver were significantly affected by combined stress (Table 1). Shoot height and shoot weight of stressed plants were reduced significantly. But root height and root weight had no significant increasing in -6 bars compared to non-stressed plant. It is presumed that the application of both drought and salt stress in combination contributed to the significant change in the water status of the soil (Siddiqui et al., 2008). On the base of Siddiqui et al., (2008) researches as a result the water uptake was severely causing a reduction in shoot height and shoot weight. However, according to Truong et al. (2002) report increase in root height and root weight may be due to vetiver strong and massive root system, which is vertical in nature descending 2-3 meters in the first year. The depth of root structure provides the plant with great tolerance to drought, permits excellent infiltration of soil moisture and penetrates through compacted soil layers. Under dry land salinity conditions, once established this deep root system can exploit the less saline subsoil moisture.

The combined stresses of drought and salt in -10 bars aridity level treatments caused a considerable reduction in root height and root weight. The responses to water and salt stress have been considered mostly identical (Munns, 2003). Drought and salinity share a physiological water deficit (Chaves et al., 2009). So aridity and drought combined stress increment, cause to vetiver water deficit. Water deficit potency is very high in -6 bars×40 dS m⁻¹ and -10 bars×40 dS m⁻¹ treatments and causing plant death (Table 1).

Results of this research showed the highest and lowest amount of leaf area was seen in Fc×4 dS m⁻¹ and -10 bars×40 dS m⁻¹ treatments. In this study, mean leaf area ranged from 0 to 5.8 cm². Leaf area and water content of vetiver was significantly reduced under the combined stress more than the unstressed plants (Table 1). This result is in agreement with Hanson and Hitz (1982) research that stated drought and salinity interaction caused to leaf area and water content reduction. Drought and salinity share a physiological water deficit that attains (Chaves et al., 2009). So water deficit has a significant effect on leaf area and growth of leaves by reducing the rate of photosynthesis.

Decrease of photosynthesis is often related to reduction of pigment content caused by inhibition of their synthesis or increased destruction as well as damage to chloroplasts (Kawamitsu, 2000; Nasser, 2001). In the
present study, the concentrations of chlorophyll in plant tissue under -6 bars×20 dS m⁻¹ and -6 bars×30 dS m⁻¹ is higher than that in other treatments (Table 1) which can be attributed to an important mechanism lead to higher photosynthetic capacity and carbohydrate formation under salinity (Zhang et al., 2012). The increasing of chlorophyll content under salinity and drought stress was observed on previous study as well (Wang and Nil, 2000; Kafi and Mahdavi, 2012; Bassman and Robberecht, 2006). But based on Chaves et al., (2009) report, salinity and drought cause to water deficit. Water deficit potency is very high in -6 bars×40 dS m⁻¹ and -10 bars×40 dS m⁻¹ treatments and causing plant death (Table 1).

5 CONCLUSION
Vetiver can growth in 40 dS m⁻¹ salinity and -10 bars drought level. This plant can growth in -10 bars×40 dS m⁻¹ combination of salinity and drought treatment.

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اثر تنش شوری و خشکی بر رشد نهال و صفات فیزیولوژی وتیور گراس (Vetiveria zizanioides Stapf) دايد اخضزی*1 ي فزَاد قاسمی آقثاش1

چکیده
تیثار نهال و صفات فیزیولوژی وتیور گراس (Vetiveria zizanioides Stapf) گونه‌های است که در شرایط مختلف آب و خاک نهال رشد دارد. به منظور مطالعه اثر تنش شوری و خشکی بر رشد این گونه گیاهی، طرح آزمایشی کاملاً تصادفی در 5 تکرار طراحی شد. بذر در گلخانه و در گلدان کشت شدند. سطوح شوری 0 (شاهد)، 20، 40 و 60 درصد زمینس بر متر و سطوح خشکی مثبت بر ظرفیت زراعی، ۴ و ۱۰ بر بودند. نتایج نشان داد که بخش شوری بر عوامل طول ساقه و ریشه و وزن ساقه و ریشه مقدار محتوای آب و محتوای کلروفیل در سطح شوری ۲۰ و ۴۰ درصد زمینس بر متر معنی‌دار است. صلیب و وزن ریشه در سطح شوری ۲۰ و ۴۰ درصد زمینس بر متر اختلاف معنی‌داری با سطح شاهد دارند. محتوای آب و محتوای کلروفیل در تیمار با شوری ۴۰ درصد زمینس بر متر و سطح خشکی ۱۰-بار بیشترین مقدار بود. محتوای آب و محتوای کلروفیل در تیمار با شوری ۴۰ درصد زمینس بر متر و سطح خشکی طرفیت زراعی کمترین مقدار بود. نتایج تحقیق خاص نشان داد که در سطح شوری ۵۰ درصد زمینس بر متر که خشکی خاک در حد ۶-۱۰-بار است، گونه گیاهان شوری‌سازید، مراتع، شوری خاک، گونه‌های خشکی پسند

کلمات کلیدی: گیاهان شوری‌سازید، مراتع، شوری خاک، گونه‌های خشکی پسند