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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

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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

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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).

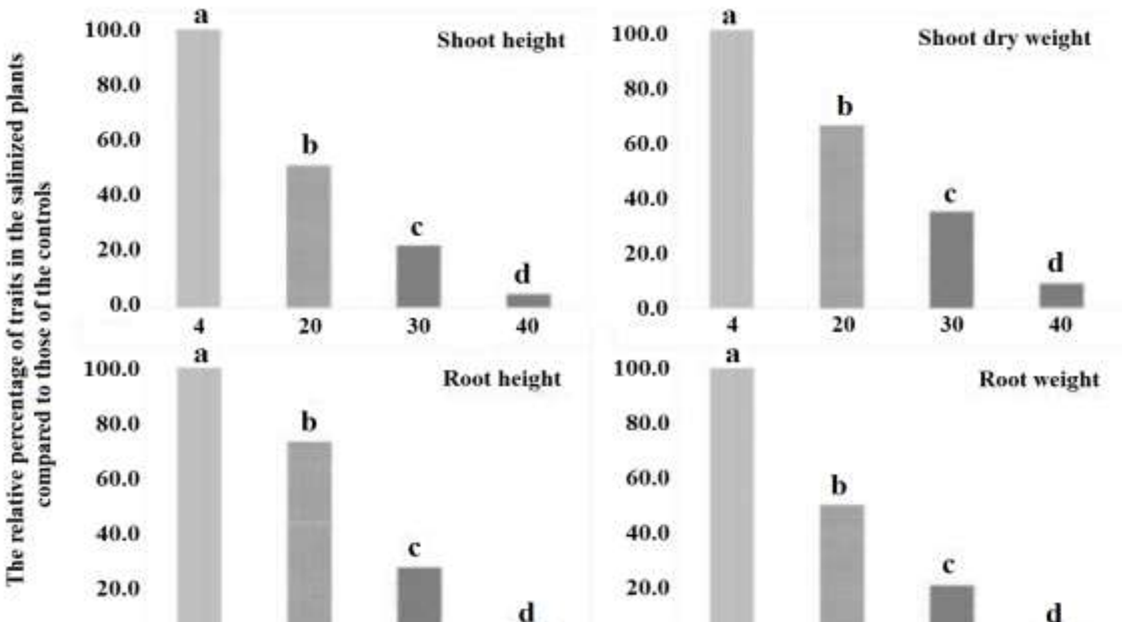

Figure 1 Relative percentage of the shoot height, shoot dry weight, root length, and root weight of salinized plants compared to those of the controls. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD) (A: shoot height, B: shoot weight, C: root length and D: root weight)

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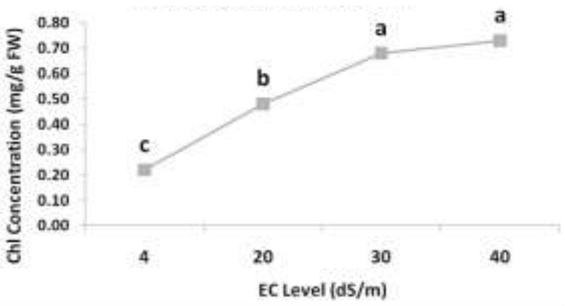

Figure 2 Effects of various salinity levels on chlorophyll concentration. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

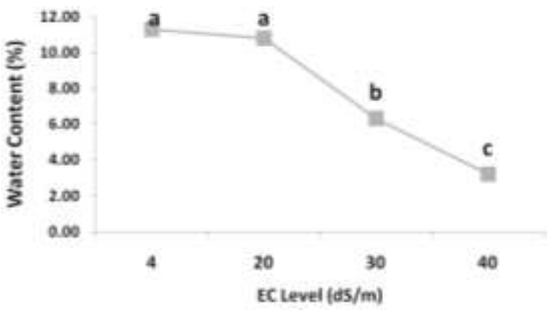

Figure 3 The effect of salinity on total leaf area in vetiver. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

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 increated 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.

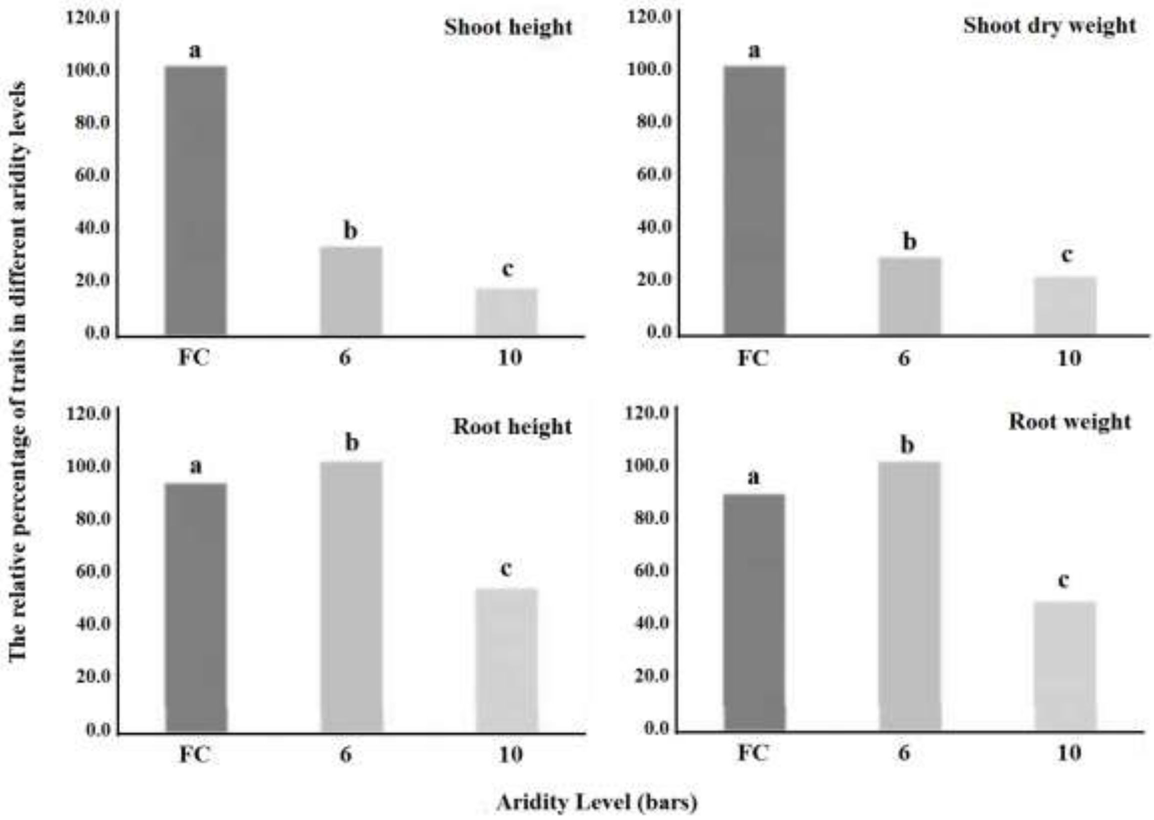

Figure 4 Effect of aridity on root and shoot dry weights of *Vetiveria zizanioides*. Different letters represent a significant difference ($P<0.05$) between treatments. (A: shoot height, B: shoot weight, C: root length and D: root weight)

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.

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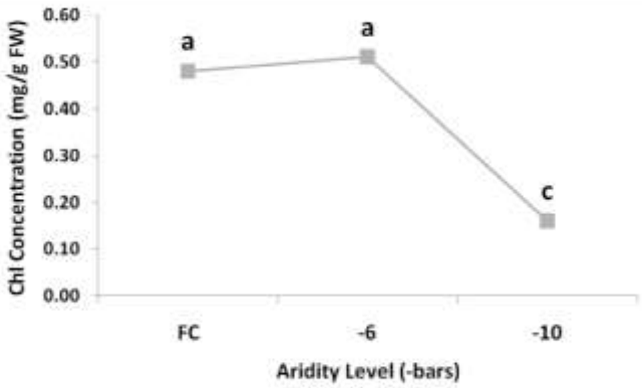

Figure 5 Effects of various aridity levels on chlorophyll concentration. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

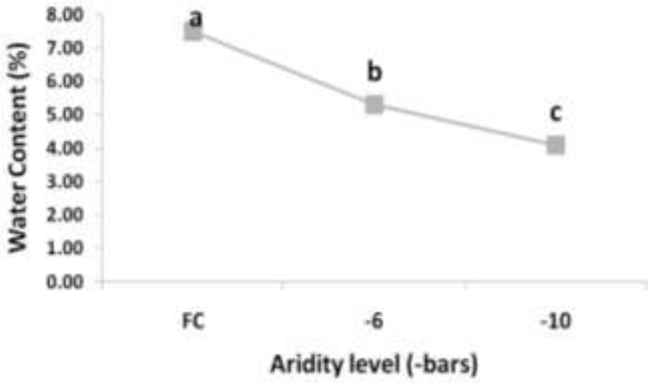

Figure 6 Effects of various aridity levels on leaves water content. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

Table 1 Effect of salinity on leaf area (cm^2), 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

Salinity	Leaf Area	Shoot Height	Shoot Weight	Root Height	Root Weight	Chlorophyll Concentration	Water Content
Fc×4 dS m^{-1}	5.8 a	0.42 a	0.44 a	0.31 a	0.43 a	0.43 c	0.78 a
-6 bars×4 dS m^{-1}	4.2 b	0.40 a	0.35 b	0.32 a	0.45 a	0.45 c	0.53 b
-10 bars×4 dS m^{-1}	3.2 c	0.27 bc	0.16 c	0.14 c	0.19 c	0.11 d	0.43 cd
FC×20 dS m^{-1}	3.3 c	0.40 a	0.34 b	0.27 b	0.28 b	0.47 bc	0.52 b
-6 bars×20 dS m^{-1}	2.1 d	0.32 b	0.18 c	0.28 b	0.32 b	0.51 ab	0.38 d
-10 bars×20 dS m^{-1}	1.7de	0.21 c	0.11 c	0.16 c	0.11 d	0.13 d	0.21 e
Fc×30 dS m^{-1}	2 d	0.14 d	0.06 e	0.07 e	0.04 ef	0.49 b	0.36 d
-6 bars×30 dS m^{-1}	1.1 f	0.08 e	0.01 ef	0.09 ef	0.06 ef	0.52 a	0.14 f
-10 bars×30 dS m^{-1}	0 g	0.01 f	0.1 ef	0.03 f	0.02 f	0.08 ef	0.08 gh
FC×40 dS m^{-1}	1.8 de	0.11 de	0.01 ef	0.05 ef	0.04 ef	0.51 ab	0.06 gh
-6 bars×40 dS m^{-1}	0 g	0 f	0 f	0 f	0 f	0 f	0 h
-10 bars×40 dS m^{-1}	0 g	0 f	0 f	0 f	0 f	0 f	0 h

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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 glycineb etaine 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; Patcharee and MongKon, 2001; 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

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content of the plant by increasing the activity of the chlorophyll degrading enzyme: cholorophyllase (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 -10bars 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

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was seen in -6bars aridity level. In fact, by reducing the leaf surface of the plant in stress conditions reduced the transpiration level to prevent the wasted water and therefore, despite reducing the total amount of chlorophyll in leaves the chlorophyll content increases per unit of leaf area (Bohrani and Habili, 1992).

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). Decrease in water content of under drought stress may depend on plant vigor reduction (Liu *et al.,* 2002). Under water deficit, cell membrane subjects to changes such as penetrability and decrease in sustainability (Blokhina *et al.,* 2003). Microscopic investigations of dehydrated cells, revealed damages including cleavage in the membrane and sedimentation of cytoplasm content (Blackman *et al.,* 1995). Probably, in these conditions, ability to osmotic adjustment is reduced (Meyer and Boyer, 1981). It seems that concentration of appropriate solutes to preserve membrane is not sufficient in this case.

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

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 5.8cm^2. 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

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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.

6 REFRENCES

Abdalla MM El-Khoshiban NH The influence of water stress on growth, elative water content, photosynthetic pigments, some metabolic and hormonal contents of two *Triticium aestivum* cultivars. J. Appl. Sci., 2007; 3: 2062-2074.

Akhzari D, Sepehry A, Pessarakli M, Barani H Studying the effects of salinity, aridity and grazing stress on the growth of various halophytic plant species (*Agropyron elongatum*, Kochia prostrata, and Puccinellia distans). World Appl. Sci. J., 2012; 17: 1278-1286.

Alizadeh A Water, soil and plant relationship. Ferdowsi University Publication, Mashhad, Iran, 1999; 351P.

Amirjani MR Effect of NaCl on some physiological parameters of Rice. Env. J. Biol. Sci., 2010; 3(1): 6-16.

Arndt SK, Clifford SC, Wanek W, Jones HG, Popp M? Physiological and morphological adaptation of the fruit tree Ziziphus rotundifollia in response to progressive drought stress. Tree Physiol., 2001; 21: 705-715.

Ashraf M, Mukhtar N, Rehman S, Rha ES Salt-induced changes in photosynthetic activity and growth in a potential plant Bishop,s weed (*Ammolei majus* L.). Photosynthetica, 2004; 42: 543-50.

Ashraf M, Neilly MC, Bradshaw A D The potential for evolution of salt (NaCl) tolerance in seven grass species. New Phytologist, 1986; 103: 299-309.

Baher ZF, Mirza M, Ghorbanli M, Rezaii MB The influence of water stress on plant height, herbal and essential oil yield and composition in Satureja hortansis L. Flavour Frag. J., 2002; 17: 275-7.

Bargali K, Tewari A Growth and water relation parameters in drought-stressed Coriaria nepalensis seedlings. Arid Environ., 2004; 58: 505-512.

Bassman JH, Robberecht R Growth and gas exchange in field-grown and greenhouse-grown *Quercus rubra* following three years of exposure to enhanced UV-B radiation. Tree Physiol, 2006; 26(9): 1153-1163.

Blackman SA, Obendorf RL, Lepold AC. Desiccation tolerance in developing soybean seeds: The role of stress proteins. Plant Physiol., 1995; 93: 630-638.

Blokhina O, Virolainen E, Fagerstedt KV Anti-oxidative damage and oxygen deprivation stress. Ann. Bot., 2003; 91: 179-194.

Bohrani M, Habili N Physiology of plants and their cells. Translation. Chamran University publication, 1992; 20-34.

Bruce B, Gregory W, Barker OE Molecular and physiological approaches to maize improvement for drought tolerance. J. Botany, 2002; 53: 13-25.

Chaum S, Kirdmanee C Effect of salt stress on proline accumulation, photosynthetic ability and growth characters in two Maize cultivars. Pakistan J. Botany, 2009; 41(1): 87-98.

Chaves MM, Flexas J, Pinheiro C Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Annals of Botany, 2009; 103: 551-560.

Chaweevan S, Suthathorn P, Churmsuwan C Study on the Effect of Salinity on Growth of Vetiver Grass. Proceeding of the First International Conference on Vetiver: A miracle Grass February, Chiang Rai, Office of the royal development project board Bangkok, Thailand. 1996; 142.

Colom MR, Vazzana C Water stress effects on three cultivars of Eragrostis curvula?. Italy J. Agron, 2002; 6: 127-32.

Cook G. The soil salinity tolerance of vetiver grass species cropped with two native Australin species. Vetiver Newsletter, 1993; 10: 180-181.

Du L, Truong P Vetiver grass for sustainable agriculture on adverse soils and climate in South Vietnam. Nong Lam University Publication, 2000; 1-13.

Flexas J, Medrano H Drought-inhibition of photosynthesis in C3 plants: stomatal and non-stomatal limitations revisited. J. Botany, 2002; 89: 183-9.

Fotovat R, Valizadeh M, Toorehi M Association between water-use-efficiency components and total chlorophyll content (SPAD)in wheat (*Triticum aestivum* L.) under well-watered and drought stress conditions. J. Food, Agric. Environ., 2007; 5: 225-227.

Fraser B Vetiver Grass: The Hedge against Erosion. The World Bank Publication. 1993; 1-48. Washington, D.C.

Gazal RM, Kubiske ME Influence of initial root length on physiological responses of cherry bark oak and shumard oak seedling to field drought conditions. J. Forest Ecol. Manage., 2004; 189: 295-305.

Hamada AM Effect of NaCl, water stress or both on gas exchange and growth of wheat. Biol. Plant., 1996; 38: 405-412.

Hanson AD, Hitz WD Metabolic responses of plant water deficit. Annual Review of Plant Physiology 1982; 33, 163-203.

Jafari M. Evaluation of salt tolerance in some Iranian rangeland grasses. Journal of Iranian Institute of Rangeland and Forest Researches, 1994; 1: 28-31.

Jagtap V, Bhargava S, Sterb P, Feierabend J Comparative effect of water, heat and light stresses on photosynthetic reactions in Sorghum bicolor (L.) Moench. J. Exp. Biol. Botany, 1998; 49: 1715-1721.

Jongrungklang N, Toomsan B, Vorasoot N, *et al.* Identification of peanut genotypes with high water use efficiency under drought stress conditions from peanut germplasm of diverse origins. Asian J. Plant Sci., 2008; 7: 628-638.

Jungai M, Chai M, Shi F Effects of long-term salinity on the growth of the halophyte Spartina alterniflora Loisel. African J. Biotechnol., 2011; 10: 17962-17968.

Kachout SS, Mansoura AB, Jaffel K, Jogloy S, Kesmala T, Patanothai A The effect of salinity on the growth of the halophyte Atriplex hortensis (Chenopodiaceae). Appl. Ecol. Environ. Res., 2009; 7: 319-332.

Kafi M, Mahdavi A Environmental stresses tolerance mechanisms. Ferdowsi University Publication, Mashhad, Iran, 2012; 466P.

Kameli A, Losel DM Growth and sugar accumulation in durum wheat plants under water stress. New Phytol., 1996; 132: 57-62.

Kawamitsu Y, Driscoll T, Boyer JS Photosynthesis during desiccation in an Intertidal Alga and a Land Plant. Plant Cell Physiol., 2000; 41(3): 344-353.

Khan MA, Irwin A, Allan MS The effect of salinity on the growth, water status and ion content of a leaf succulent perennial halophyte, *Suaeda fruticosa* L. Arid Environ. J., 2000; 45: 73-84.

Kyparissis A, Petropoulou Y, Manetas Y Summer survival of leaves in a soft-leaved shrub (Phlomis fruticosa L., Labiates) under, 1995.

Lauchli A, Epstein E Plant responses to saline and sodic conditions and Agricultural Salinity Assessment and Management, 1990; 113-37. ASCE, New York.

Lazof D, Bernstein N The NaCl-induced inhibition of shoot growth: the case for disturbed nutrition with special consideration of calcium nutrition. Adv. Bot. Res., 1998; 29: 113189.

Lessani H, Mojtahedi M Introduction to Plant Physiology (Translation). 6th Edn., Tehran University press, Iran, ISBN: 2002; 964-03-3568-1, 726.

Li C, Wang K Differences in drought responses of three contrasting Eucalyptus microtheca F. Muell populations. J. Forest Ecol. Manage., 2003; 179: 377-385.

Liu Y, Fiskum G, Schubert D Generation of reactive oxygen species by mitochondrial electron transport chain. J. Neurochem, 2002; 80: 780-787.

Loch R Vetiver grass. Landloch University Publication, 2006; 1-2.

Masoudi P, Gazanchian A, Jajarmi V, Bozorgmehr A Effect of seed priming on germination improvement and seedling vigor in three perennial grass species under saline conditions. J. Agr. Sci. Technol., 1997; 22: 57-67.

Metzner R, Litwin G, Weil G The relation of expectation and mood to psilocybin reactions: a questionnaire study. – Psychedelic Rev. 1965; 5: 3-39.

Meyer RF, Boyer JS Osmoregulation solute distribution and growth in soybean seedlings having low water potentials. Planta, 1981; 151: 482-489.

Munns R Comparative physiology of salt and water stress. J. Plant Cell Environ., 2003; 25: 239-50.

Nanakorn M, Surawattananon M, Namwongprom S In vitro selection of NaCl tolerance in vetiver species. Proceeding of the First International Conference on Vetiver: A miracle Grass. February, Chiang Rai, Office of the royal development project board Bangkok, Thailand. 1996; 32.

Nasser LA Effects of UV-B radiation on some physiological and biochemical aspects in two cultivars of barley (*Hordeum vulgare* L.). Egyptian Journal of Biology, 2001; 3: 97-105.

Netting AG pH, abscisic acid and integration of metabolism in plants under stressed and non-stressed conditions: cellular response to stress and their implication for plant relations. J. botany, 2000; 343: 147-158.

Omidi H Changes of proline content and activity of antioxidative enzymes in two canola genotype under drought stress. American J. Plant Physiology, 2010; 5: 338-349.

Patcharee T, MongKon T Effect of Salinity on Vetiver grass Grass Growth. In: The 39th Kasetsart University Annual Conference, Bangkok. 2001.

Rad MH, Assare MH, Banakar MH, Soltani M Effects of Different Soil Moisture Regimes on Leaf Area Index, Specific Leaf Area and Water use Efficiency in Eucalyptus (Eucalyptus camaldulensis Dehnh) under Dry Climatic Conditions. Asian J. Plant Sci., 2001; 3: 132-139.

Rao GG, Rao GR Pigment composition & chlorophyllase activity in pigeon pea (Cajanus indicus Spreng) & Gingelley (Sesamum indicum L.) under NaCl salinity. Indian J. Exp. Biol., 1981; 19: 768-770.

Rensburg LV, Kruger GH Evaluation of components of oxidative stress metabolism for use in selection of drought tolerant cultivars of *Nicotiana tabacum* L. J. Plant Physiology, 1994; 143:730-737.

Richards L Diagnosis and improvement of saline and alkaline soils. Handbook No: 60. United States Department of Agriculture, Washington DC, 1954; 160P.

Rout NP, Shaw BP Salt tolerance in aquatic macrophytes: Ionic relation and interaction. Biology of Plant, 2001; 55: 91-5.

Schlemmer MR, francis DD, Shanahan JF, Schepers JS. Remotely measuring chlorophyll content in corn leaves with differing nitrogen levels and relative water content. Agron. J., 2005; 97:106-112.

Sepehry A, Akhzari D, Pessarakli M, Brani H Studying the effects of salinity stress on the growth of various halophytic plant species (Agropyron elongatum, Kochia prostrata, and Puccinellia distans). World Appl. Sci. J., 2012; 16: 998-1003.

Sharp RE, Davies WJ Root growth and water uptake by plants in drying soil. J. Botany, 1985; 36: 1441-1456.

Sharp RE, Davies WJ Solute regulation and growth by roots and shoots of water-stressed plants. J. Planta, 1979; 147: 43-49.

Siddiqui ZH, Ajmal Khan1 M, Kim BG, Huang JS, Kwon TR Physiological Responses of Brassica napus Genotypes to Combined Drought and Salt Stress. Plant Stress 2008; 2(1): 78-83.

Smirnoff N Antioxidant systems and plant response to the environment. In: Smirnoff V (Ed.), Environment and Plant Metabolism: Flexibility and Acclimation, BIOS Scientific Publishers, Oxford, UK. 1995.

Tabaee Oghdaee R Environmental tolerance potency in some rangeland grasses. Journal of Pajouhesh and Sazandegi, 1999; 40: 41-45.

TruongNI, Gordon F, Armstrong M Vetiver grass for saline land rehabilitation under tropical and Mediterranean climate. Productive Use and Rehabilitation of Saline Lands National Conference, Fremantle, Australia. 2002.

Vimala Y, Kataria K Physico-Chemical Study of Vetiver in Wetland Soil Reclamation.

J. Botany, 2005; 3: 422-426.

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

Zhang Z, Liu Q, Song HX, Rong XM, Abdelbagi MI Responses of different rice (Oryza sativa L.) genotypes to salt stress and relation to carbohydrate metabolism and chlorophyll content. African J. Agr., 2012; 7(1): 19-27.

اثر تنش شوری و خشکی بر رشد نهال و صفات فیزیولوژی وتیور گراس (*Vetiveria zizanioides* Stapf)

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چکیده *Vetiveria zizanioides* گونه‌ای است که در شرایط مختلف آب و خاک توان رشد دارد. به منظور مطالعه اثر تنش شوری و خشکی بر رشد این گونه گیاهی، طرح آزمایشی کاملاً تصادفی در ۵ تکرار طراحی شد. بذور در گلخانه و در گلدان کشت شدند. سطوح شوری ۴ (شاهد)، ۲۰، ۳۰ و ۴۰ دسی زیمنس بر متر و سطوح خشکی مبتنی بر ظرفیت زراعی، ۶- و ۱۰- بار بودند. نتایج نشان داد که اثر شوری بر عوامل طول ساقه و ریشه، وزن ساقه و ریشه، مقدار محتوای آب و محتوای کلروفیل در سطح شوری ۲۰ دسی زیمنس بر متر معنی‌دار نیست. اثر سطوح شوری ۳۰ و ۴۰ دسی زیمنس بر متر بر عوامل یاد شده معنی‌دار است. طول و وزن ریشه در سطوح شوری۲۰ و ۳۰ دسی زیمنس بر متر اختلاف معنی‌داری با سطح شاهد دارند. محتوای آب و محتوای کلروفیل در تیمار با شوری۴۰ دسی زیمنس بر متر و سطح خشکی۱۰- بار بیشترین مقدار بود. محتوای آب و محتوای کلروفیل در تیمار با شوری ۴ دسی زیمنس بر متر و سطح خشکی ظرفیت زراعی کمترین مقدار بود. نتایج تحقیق حاضر نشان داد که در سطح شوری۲۰ تا ۳۰ دسی زیمنس بر متر که خشکی خاک در حد ۶- تا ۱۰- بار است، گونه *Vetiveria zizanioides* برای بهبود خاک مناسب است.

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