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Evaluation of Barley Productivity and Water Use Efficiency under Saline Water Irrigation in Arid Region

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ABSTRACT: The aims of this study were to study the effect of salinity concentrations (0.35, 2, 4, 6, 8 and 10 dS m^{-1}) on physiological aspects and yield traits as well as water use efficiency (WUE) of eight barley cultivars. Results indicated that irrigate barley with saline water until 6 dS m^{-1} is favorable to obtain a suitable yield. Cultivars were significantly different in most characters were examined. Wadi Otba-1 was superior in grain yield. In this concern, under irrigation water reached to 6 dS m^{-1} the Wadi Otba-1, Wadi Otba-2, Tesa and Anaser cultivars are suitable for producing high yield. Regarding to corresponding WUE was decreased with increasing salinity. The maximum WUE were 2.62 and 2.78 g/l under 2 dS m^{-1}, while the minimum WUE were 1.58 and 1.69 g/l under 10 dS m^{-1}. The highest WUE values (3.64, 3.58 and 3.59 g/l) were obtained from Wadi Otba-1 irrigated with the lower salinity levels (0.35, 2 and 4 dS m^{-1}). Meanwhile, the lowest WUE (0.64, 0.95 and 0.98 g/l) were recorded when Aryl, Barjoj and Berangene were irrigated with high salinity level (10 dS m^{-1}), respectively. Based on the results, it can be said that, high yielding cultivars has more spike number and grains number per spike with higher chlorophyll and soluble sugar content considering could be adaptive for high WUE .Consequently, under irrigation water reached to 6 dS m^{-1} the cultivars WO1, WO2 and Tesa are suitable for producing high yield under saline conditions in semi-arid and arid region.
Keywords: Barely, Grain yield, Growth, Saline stress, Water Use Efficiency

INTRODUCTION

Cereals are cultivated in more or less every region of the world and their growth and yield reduces due to adverse environmental cues (Shahbaz and Ashraf, 2013). Of common cereal crops, barley is generally categorized salt tolerant although cultivars show significant variation (Witzel et al., 2009). However, a difference in the salt tolerance among genotypes may also occur at different growth stages. Barley (*Hordeum vulgare* L.*)* is one of the most important crop species in the world. Barley is tolerant to salinity (Chen et al., 2007). The barley (Hordeum vulgare L.) is widely cultivated in the semi-arid regions for pasture and grain production (Oueslati et al., 2005).

Salinity is one of the key environmental factors that adversely influence crop productivity in several regions of the world (Shahbaz and Ashraf, 2013; Ashraf and Foolad, 2013). Salinity induces water deficit even in well watered soils by decreasing the osmotic potential of soil solutes thus making it difficult for roots to extract water from their surrounding media (Sairam et al., 2002). The effect of high salinity on plant can be observed at the whole plant level in terms of plant death and/or decrease in productivity (Parida et al., 2004).

To overcome water shortages and to satisfy the increasing water demand for agricultural development, the use of marginal quality waters (brackish, reclaimed, drainage) will become necessary in many countries. However, the use of saline water for irrigation requires an adequate understanding of how salts affect soil characteristics and plant performance (Chartzoulakis et al., 2002). According Andarzian et al. (2011) one of the most important factors in the planned irrigation is water use efficiency (WUE) or amount dry matter production per unit of water used that it's determining factors, economic yield, biological yield and water consumption can be named. Reducing water use by decreasing the transpiration rate is also a positive mechanism that can help to conserve water and reduce salt loading in the plant (Romero-Aranda et al., 2001).WUE decreased with increasing salinity levels (Yurtseven et al., 2005).

A better understanding of physiological responses under salinity may help in programs in which the objective is to improve the salt tolerance of crop varieties.Therfor, the present study aimed to evaluate and assess the effect of saline stress on some physiology and agronomical traits of eight barley cultivars and water use efficiency.

MATERIALS AND METHODS

General and plant material

Pots experiment was conducted in the farm of the faculty of Agriculture, Sebha University- Libya during the two winter seasons of 2008/2009 and 2009/2010 to investigate the effect of six concentrationbs of saline water on the some physiological ,agronomical traits and water use efficiency of eight barley cultivars. The barley plants were grown in pots, 30 cm in diameter and 40 cm deep. The soil was collected from experimental farm of the Faculty of Agriculture, Sebha University. Soil was air-dried and passed through a 2mm sieve and filled in pots. Each pot was filled with 5.5 kg of air-dried soil. The soil used in the experimental is sandy (93.90 % sand, 4.00 % silt and 2.10 % Clay). Some chemical properties of the experimental soil are given in (Table 1). Double ammonium phosphorus fertilizer (P_2O_5 46%, N 18%) was mixed by soil before planting at rate 160 kg N /ha and 120 kg P_2O_5 /ha, the residual of N was added to each treatments as a urea on three doses. The first dose added at tillering stage, second at stem extension stage and third at booting stage. The rate of dose calculated depending on the total area of pot.

Table 1. Some chemical characteristics of the soil used for the experiment

Parameters	2008/2009	2009/2010
pH	7.5	7.5
Calcium Carbonate (%)	6.4	6.2
CEC (meq/100 g soil)	4.9	5.1
P (mmol/kg)	1.1	0.9
K (mmol/kg)	6.8	7.1
N (mmol/kg)	Nill	Nill

Treatments and procedures

Barley cultivars

Barley cultivars included eight cultivars as follows: Wadi Otba-1 (WO1), Wadi Otba-2 (WO2), Flik4, Berangene (Ber.), Tesa, Aryl, Barjoj (Barj.) and Anaser (Anas.). The barley varieties were sown on 1 and 7 of December in both seasons 2008 -2009 and 2009-2010, respectively, at a rate of 20 seeds per pot. Fresh water was used for seed emergence. When the seedlings were well developed, the plants were thinned out to 15 seedlings per pot after Three weeks from sowing.

Irrigation water salinity levels

Six water salinity concentrations were used for irrigation: T_0 fresh water (as a control) with on EC of 0.35 dS m^{-1}, T_1= 2, T_2= 4, T_3= 6, T_4= 8 and T_5= 10 dS m^{-1}. The saline water was obtained by adding the equivalent amounts of NaCl to the fresh water. Barley plants in each pot were irrigated at two days intervals by amounts of the saline water, the minimum and maximum amount of applied water to each pot varied between 0.26 to 1.6 liters/pot per irrigation in January and April, respectively. The crop received a total of 75 irrigations during the whole growth period. The total quantity of irrigation water applied was 51.6 l/pot (equivalent to 730.9 mm depth of water) for the total growing period of 160 days.

Measurement and water use efficiency

The amount of applied water to each pot was determined by using the crop water requirements (ETc). To calculate (ETc), first of all estimate daily evapotranspiration **(**ETO), then ETc was calculated as follows:

The daily evapotranspiration (ETO)

The daily ETO was computed according to the equation of FAO-PM (Allen et al., 1998) as follows:

$$ETo = \frac{0.408\ \Delta\left(R_n - G\right) + \gamma\ \frac{900}{T_{\text{mean}} + 273} u_2\ (e_s - e_a)}{\Delta + \gamma\left(1 + 0.34\, u_2\right)}$$

Where:

Δ =Slope of the saturation vapor pressure curve at air temperature (kPa °C-1), Rn =Net radiation at the crop surface (MJm-2 d-1), G = Soil heat flux density (MJm-2 d-1), γ=Psychometric constant = (0.665×10-3×P), kPa 0C1 (Allen et al., 1998), P =atmospheric pressure (kPa), U_2=Wind speed at 2 m height (m s-1), es=Saturation vapor pressure (kPa), es=Saturation vapor pressure (kPa), ea=Actual vapor pressure (kPa), (es – ea)=Saturation vapor pressure deficit (kPa), Tmean =Mean daily air temperature at 2 m height (°C). The average daily ETO at Sebha region was estimated using the monthly mean weather data of Sebha Meteorological station. The average of daily ETO at Sebha was 3.88, 3.69, 4.73, 7.14 and 9.86 ETO mm /day at Dec., Jan., Feb., Mar. and April months, respectively.

The crop water requirements (ETc)

The crop water requirements (ETc) were estimated using the crop coefficient according to the following equation: ETc= (ETO × Kc), Where: ETc=Crop water requirements, mm/day, Kc = Crop coefficient. The lengths of the different crop growth stages were 20, 50, 60, and 30 days for initial stage, crop development stage, mid-season stage and late season stage, respectively. According to Allen et al. (1998) the crop coefficients (Kc) of initial, mid and end stage were 0.30, 1.15 and 0.25, respectively.

Water use efficiency (WUE)

Water use efficiency (WUE) values as g seed L^{-1} of appliedwater were calculated for different treatments after harvest according to the followingequation (Jensen, 1983).

$$WUE = \frac{\text{Grain yield (g plot}^{-1})}{\text{Water applied (L plot}^{-1})}$$

Chlorophyll, carotene and soluble sugar ratio: were determined in most critical stages of growth (i.e. Tillering ZGs12, Elongation ZGs32 and Booting ZGs49 (Zadoks et al., 1974), according to Comar et al. (1941) and Joslyn (1970).

Harvest of plants: after complete maturity, the plants of each pot were harvested and threshed manually, divided to straw and grain and dried for 18 h at 70°C and were recorded (Number of spikes per plant, number of grains per spike, 1000 grain weight, straw and grain yield).

Statistical methods: The experiment was arranged in a randomized complete block design with three replications, where the varieties and water salinity levels treatments were allocated in the main-plot and sub-plot, respectively. Data were analyzed with analysis of variance as procedure outlined by Gomez & Gomez (1984). Differences between the means were compared using revised least significant range test ($p< 0.05$).

RESULTS AND DISCUSSION

Effect of water salinity

The pattern of change in chlorophyll (a + b) /car.ratio in response to water salinity was similar to those of soluble sugar ratio (Table 2). These traits in all growth stages were significantly decreased by increasing water salinity in both seasons.The highest values of chl (a + b)/car. ratio and soluble sugar ratio were recorded when barley plants were irrigated with water of 2 dS m^{-1}, while subjecting barley to salinity stress (10 dS m^{-1}), gave the lowest values for the respected traits .The detrimental effect of saline water on chlorophyll and soluble sugar ratio can be attributed largely to lower osmotic potential of the soil solution due to the increased concentration of salt in the root environment (Croser et al., 2001). Limitation of leafs extension and chlorophyll molecules destruction by sodium (Innocenti, 2009). Salinity can also affect traits by facilitating the uptake of toxic ions, which can cause changes to certain enzymatic or hormonal activities of the plant.The result agreement with Yildirim and Guvence (2006) and Bagci et al., (2007). Salt stress induced inhibition on plant growth could be attributed to specific ion toxicity, disturbance in homeostasis of Na^{+} and Cl ions, stomatal closure, and the increased production of ROS in chloroplasts (Gunes et al., 2007; Daneshmand et al., 2010).

Data in (Table 3) showed that the No. of spikes per plant, No. of grains per spike, straw and grain yield (GY) of barley crop were significantly affected with increasing irrigation water salinity for all the cultivars investigated. It was noticed that there was no significant difference in 1000 grain weight. The highest grain yield was produced when barley plants were irrigated with 0.35, 2, 4 and 6 dS m^{-1} levels of salinity without significant differences between them in both seasons, while the minimum values (5.45 and 5.81 19 g $plant^{-1}$) were recorded for the highest water salinity (10 dS m^{-1}), in the both seasons, respectively.

These results may be attributed mainly to the highest water salinity which inhibited plant growth and retard shoot growth much more than roots. Moreover, increasing level of salinity water induce chlorosis in plants, despite the increase in different element uptake, consequently, a reduction in cell division and enlargement could occur. Water stress, induced by water salinity, causes closer of stomata which reduces the supply of carbon dioxide for photosynthesis. This would be reflected on photosynthesis and metabolic processes. Therefore, a decrease in the size of fruiting organs and grain filling period could be obtained which would result in reducing the grain weight (El-Karamity and Atta Allah, 1997). Regarding grain yield (Figure 1), the highest reduction percentages in grain yield were recorded in plants of pots irrigated with (10 dS m^{-1}), compared with other treatments.

Table 2. (Chlorophyll a + chlorophyll b)/ carotene ratio and soluble sugar ratio of some growth stages as affected by irrigation water salinity

EC dS m^{-1}	Seasons	Chlorophyll (a + b) /car. ratio			Soluble sugar ratio		
		Growth stages					
		Tillering ZGs_{12}	Elongation ZGs_{32}	Booting ZGs_{49}	Tillering ZGs_{12}	Elongation ZGs_{32}	Booting ZGs_{49}
0.35	08-09	4/00	3/59	3/26	10/27	10/73	10/23
	09-10	4/16	3/68	3/22	10/40	11/14	10/46
2	08-09	4/03	3/63	3/26	10/30	10/75	10/12
	09-10	4/18	3/64	3/22	10/43	11/28	10/29
4	08-09	3/98	3/59	3/24	10/29	10/72	10/24
	09-10	4/18	3/62	3/19	10/42	11/15	10/23
6	08-09	3/88	3/59	3/19	10/21	10/75	10/01
	09-10	3/98	3/43	3/15	10/31	11/11	10/16
8	08-09	3/29	3/09	2/56	8/46	8/80	8/41
	09-10	3/38	3/06	2/55	5/56	9/34	8/47
10	08-09	2/71	2/24	1/77	7/00	7/32	5/68
	09-10	2/82	2/16	1/79	7/13	7/50	5/91
L.S.D. Revised (p< 0.05)	08-09	0/79	0/58	0/34	0/11	0/07	0/27
	09-10	0/83	0/71	0/38	0/21	0/28	0/52

Table 3.Yield, yield components and water use efficiency of barely plants as affected by irrigation water salinity

EC dS m^{-1}	seasons	No. spikes/ plant	No. Grain / spikes	1000 grain weight (g)	Straw (g/plant)	GY (g/plant)	WUE (g/l)
0.35	08-09	334	63/61	40/64	6/16	8/89	2/58
	09-10	3/39	65/07	41/92	6/05	9/46	2/75
2	08-09	3/36	64/26	40/71	6/16	9/02	2/62
	09-10	3/39	65/18	42/23	6/06	9/58	2/78
4	08-09	3/31	63/58	41/07	6/11	8/85	2/57
	09-10	3/33	64/45	42/63	6/04	9/35	2/72
6	08-09	3/27	62/29	41/23	6/04	8/66	2/52
	09-10	3.30	64/33	37/56	5/85	9/31	2/71
8	08-09	3.00	56/98	41/85	5/40	7/40	2/15
	09-10	3/04	57/48	43/75	5/30	7/86	2/28
10	08-09	2/45	49/58	42/53	4/50	5/45	1/58
	09-10	2/37	49/21	44/8	4/42	5/81	1/69
L.S.D. Revised (p< 0.05)	08-09	0/41	2/71	Ns	1/33	1/72	0/11
	09-10	0/48	2/41	Ns	0/90	1/22	0/09

The reduction percentages in grain yield due to the use of 8 and 10 dS m^{-1} compared 2 dS m^{-1} were 17.96 and 39.58% in the first season and 19.00 and 39.35% in the second one, respectively. From the results mentioned previously, it is imported to note that the difference between grain yields of plants irrigated with fresh water did not significant with 2, 4 and 6 dS m^{-1}. The obtained results led to conclude that irrigate barley with water salinity until 6 dS m^{-1} is favorable to obtain a suitable grain yield.

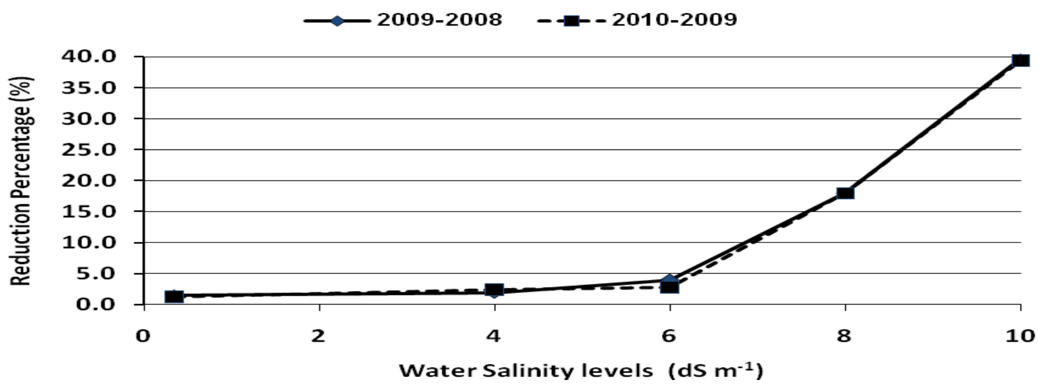

Figure 1. The reduction percentage in grain yield related to water salinity levels.

Effect of cultivars

Data presented in (Table 4) indicated clearly that chl.a + chl.b /car.ratio and soluble sugar ratio were significantly differed with different studied cultivars at all growth stages over the two growing season's .WO1, WO2, Tesa and Anas. Cultivars gave the highest values of these traits of all growth stages.While; the lowest values were achieved by Bera and Aryl cultivars, respectively.

Table 4.Chlorophyll a + chlorophyll b / carotene ratio and soluble sugar ratio of some growth stages as affected by different cultivars

Cultivars	Seasons	Chlorophyll (a + b) /car. ratio			Soluble sugar ratio		
		Growth stages					
		Tillering ZGs_{12}	Elongation ZGs_{32}	Booting ZGs_{49}	Tillering ZGs_{12}	Elongation ZGs_{32}	Booting ZGs_{49}
WO1	08-09	4/32	3/69	3/49	10/95	11/82	11/25
	09-10	4/68	3/72	3/44	11/00	12/14	11/09
WO2	08-09	4/47	3/86	3/13	11/34	12/85	11/53
	09-10	4/67	3/70	3/12	11/78	13/49	11/56
Flik	08-09	2/94	2/82	2/52	7/92	9/96	9/09
	09-10	2/90	2/76	2/51	8/69	9/39	9/40
Bera.	08-09	2/91	2/51	2/46	7/68	7/81	6/44
	09-10	2/70	2/48	2/51	7/22	7/69	6/67
Tesa	08-09	4/42	3/83	3/20	11/03	11/13	10/08
	09-10	4/49	3/81	3/13	11/12	11/91	10/77
Aryl	08-09	2/50	2/82	2/49	8/08	8/23	8/00
	09-10	2/69	2/83	2/45	8/24	9/03	7/89
Barj.	08-09	2/88	2/82	2/43	7/42	6/90	6/48
	09-10	2/96	2/89	2/69	6/99	7/14	6/67
Anas.	08-09	4/74	3/96	3/33	10/97	10/05	10/03
	09-10	5/05	3/94	3/34	11/28	11/25	10/04
L.S.D. Revised (p< 0.05)	08-09	0/48	0/31	0/48	0/62	2/89	2/34
	09-10	0/58	0/26	0/41	0/81	2/36	2/14

Table 5. Yield and yield components of barely plants as affected by different cultivars

Cultivars	Seasons	No. spikes/ plant	No. Grain / spikes	1000 grain weight (g)	Straw (g/plant)	GY (g/plant)	WUE (g/l)
WO1	08-09	3/55	73/77	41/00	7/04	10/99	3/19
	09-10	3/72	73/17	41/06	6/90	11/42	3/32
WO2	08-09	3/75	65/45	43/29	6/89	10/81	3/14
	09-10	3/77	66/06	43/33	6/69	10/96	3/19
Flik	08-09	2/47	55/16	42/66	4/60	5/97	1/74
	09-10	2/46	55/13	45/29	4/35	6/28	1/83
Bera.	08-09	2/37	50/03	43/03	4/35	5/17	1/50
	09-10	2/29	53/01	44/69	4/27	5/52	1/60
Tesa	08-09	3/76	71/45	37/89	6/97	10/36	3/01
	09-10	3/74	72/71	40/04	6/63	10/02	2/91
Aryl	08-09	2/44	53/22	40/83	4/85	5/47	1/59
	09-10	2/53	55/50	44/51	5/02	6/44	1/87
Barj.	08-09	2/95	48/96	40/25	4/69	5/88	1/71
	09-10	2/97	50/22	40/56	4/67	6/12	1/78
Anas.	08-09	3/70	62/36	41/76	6/44	9/75	2/83
	09-10	3/65	61/74	45/30	6/45	10/75	3/13
L.S.D. Revised (p< 0.05)	08-09	0/68	4/03	Ns	0/71	1/33	0/18
	09-10	0/41	7/38	Ns	0/59	0/81	0/19

The differences between the studied cultivars in plant chemical contents may be due to the cultivars in growth habit and genetically performance which affected directly on the chemical contents. These results are confirmed by those of (Akman, 2009). High accumulation of sodium in plant tissues have been reported as one of the effective factors in reduction of photosynthetic pigments and rate of photosynthesis (Ashraf, 2004).

Data in (Table 5) showed that the No. of spikes per plant, No. of grains per spike, straw and grain yield (GY) of barley crop was significantly affected by the investigated cultivars in the both seasons. But, the 1000 grain weight was no significant difference. WO-2, Tesa and Anas Cultivars produced the highest No. of spikes per plant, while the lowest one was recorded with Ber.cultivar. While, WO1 and Tesa cultivars produced the highest No. of grains per spike, but, the lowest one was recorded with Barj.Cultivar. The highest values of straw and grain yield were recorded for WO1, WO2 and Tesa cultivars. While, the lowest one was recorded for Bera.Cultivar.

The average of reduction percentages of grain yield compared with WO1 were 2.86, 8.52, 9.06, 45.34, 46.45, 46.85 and 52.30 % for WO2, Anas., Tesa, Flik4 , Barj., Aryl and Bera., respectively. Therefore, WO1, WO2, Anas., Tesa cultivars can be recommended to production of barely under sebha conditions. These results are supported by the work of Francois et al. (1994) who stated that yield components which were stressed by salinity during their development contributed less to grain yield.

Effect of interaction

Results of (Figure 2) indicate that water salinity and cultivars interaction had significant effect on chl.a + chl.b /car.ratio and soluble sugar ratio at tillering, elongation and booting stages in the first and second seasons. It is important to note that irrigated cultivars by concentrations of water salinity from 0.35 and 2 dS m^{-1} gave the greatest total chlorophyll and soluble sugar ratio, while, the lowest values of these characters were obtained by irrigated with water salinity (10 dS m^{-1}). It was reported that increase in the salt concentration of growth medium caused a significant reduction in mean chlorophyll a and chlorophyll b of rice genotypes, but this effect of salt concentrations changed depending on the genotype (Subhashini and Reddy 1990).

Results of (Figure 3) showed that the No. of spikes per plant, No. of grains per spike, 1000 grain weight, straw and grain yield (GY) of barley crop was significantly affected by irrigation water salinity and cultivars investigated in the both seasons. In general, grain yield and most of its traits for all cultivars were decreased with increasing the concentrations of water salinity from 2 to 10 dS m^{-1}. The average of highest GY (12.53 19 g $plant^{-1}$) was recorded for WO-1 cultivar irrigated with fresh water (0.35 dS m^{-1}). Whereas, the lowest GY (2.19 g $plant^{-1}$) was obtained for Aryl cultivar irrigated with the highest irrigation water salinity (10 dS m^{-1}). This difference in salt tolerance could be attributed mainly to the genetic variability among various barley cultivars as well as growing conditions. It is important to pay attention to note that the highest grain yield was recorded for WO1 cultivar irrigated with (0.35 dS m^{-1}) followed without significant differences by those irrigated by 2, 4 and 6 dS m^{-1}. Therefore, it could be concluded that under limited quality of irrigation water reached to 6 dS m^{-1} the WO1, WO2 and Tesa.Cultivars are suitable for producing relative high yield compared to anther cultivars. It is reported that reduction of yield under salt stress against control condition was used as an indicator of tolerance to salt stress (Ochiai and Matoh, 2001). In 6 dS m^{-1} compared to control, the highest yield and lowest reduction in plant yield were observed in WO1, WO2 and Tesa. It can use as a reference to determine validity of these cultivars in case of salt tolerance.

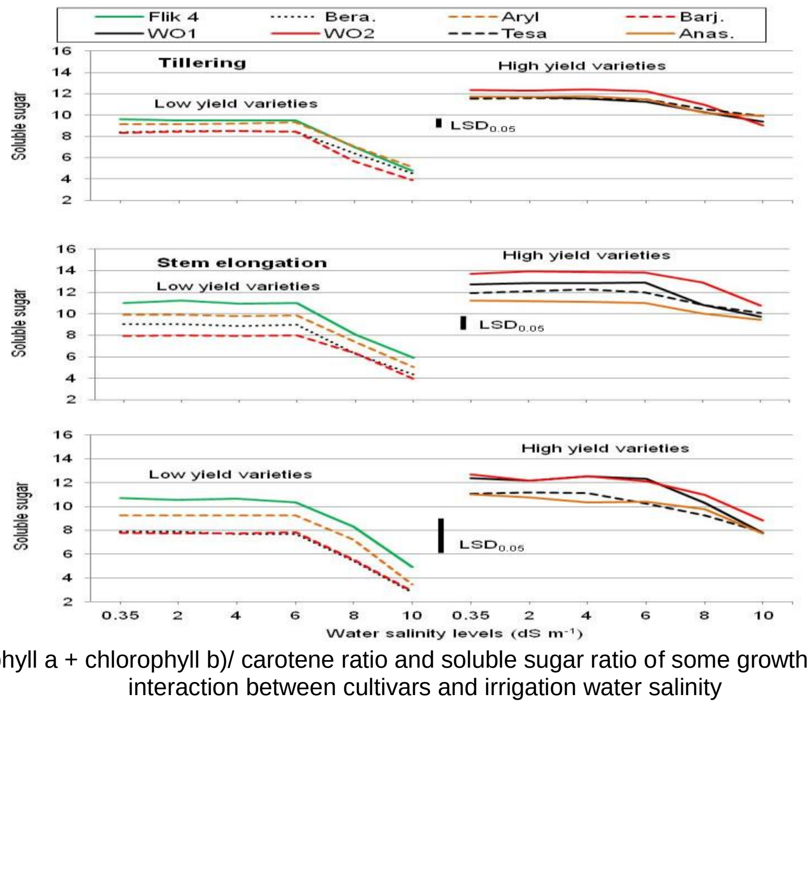

Figure 2. (Chlorophyll a + chlorophyll b)/ carotene ratio and soluble sugar ratio of some growth stages as affected by interaction between cultivars and irrigation water salinity

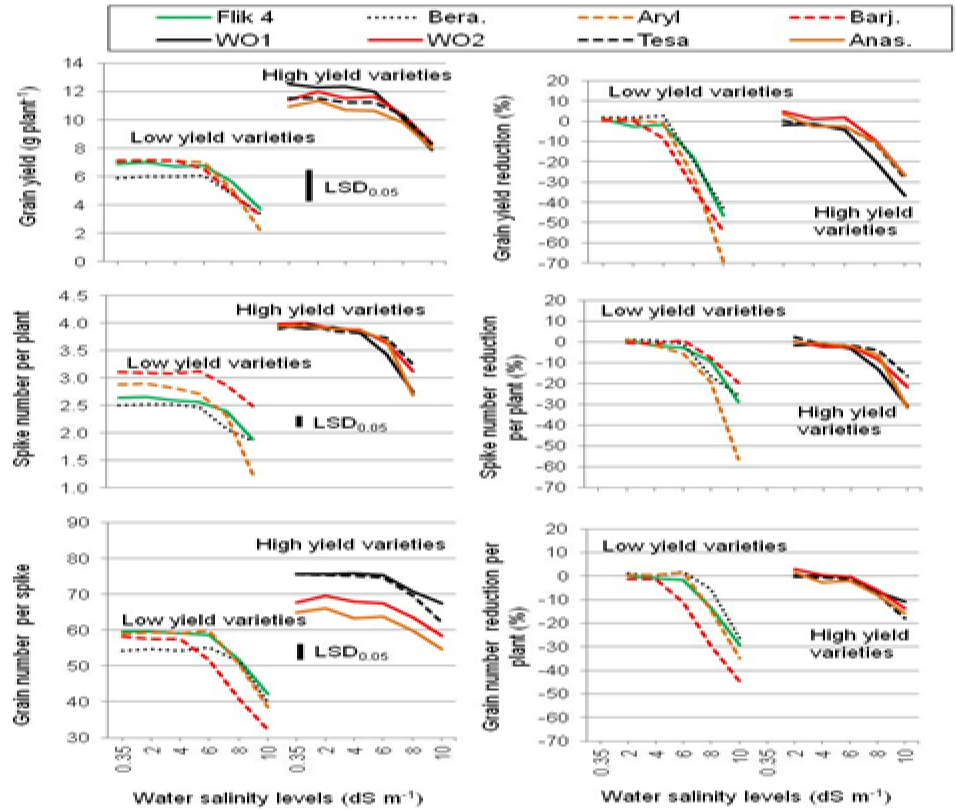

Figure 3 . Yield and yield components of barely plants as affected by the irrigation water salinity and barley cultivars

Water Use Efficiency (WUE)

The effect of water salinity concentrations on WUE is presented in (Table 3 and Figure 4). It is clear that the WUE was decreased with increasing water salinity concentrations. The obtained result agreement with those obtained by Yurtseven et al., (2005) and Grewal, (2010). The maximum WUE were 2.62 and 2.78 g L^{-1} under 2 dS m^{-1}, while the minimum WUE were 1.58 and 1.69 g L^{-1} under 10 dS m^{-1} in the first and second seasons, respectively. WUE of the eight cultivars were insignificant affected by irrigation with saline water until 6 dS m^{-1}in seasons. However, increasing water salinity to 8 and 10 dS m^{-1} had depressing effect on WUE of these eight cultivars. Increasing salinity levels from 2 to 10 dS m^{-1} decrased WUE by 1.9, 4.0, 18.0 and 39.6% in the first season and 2.4, 2.8, 18.0 and 39.4% in the second one, respectively.

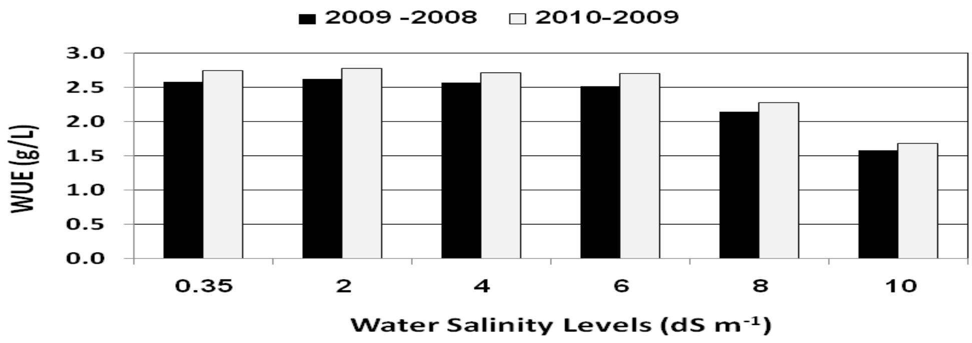

Figure 4. Water use efficiency related to water salinity in the two seasons.

As shown in (Table 5 and Figure 5) WUE was affected by barley cultivars. The maximum and minimum WUE values were 3.19 and 1.50 g L^{-1} in the first season, and 3.32 and 1.60 g L^{-1} in the second season for WO2 and Bera.Respectively. WUE of barley cultivars was in order of WO1 > WO2 > Anas. > Tesa> Flik 4 > Barj. > Aryl > Bera. Results suggest Flik 4, Barj. Aryl and Bera.to be the most sensitive to water salinity and there may be implications for irrigated those cultivars by high water salinity. Growing of comparatively tolerant cultivars like WO1, WO2 and Tesa may be the better option for sustainable crop production. It is noted that the increased salinity of water lead to reduce in use efficiency. This result was expected because of other researchers have also shown that salt lead to reduction in water use efficiency. So can point out the research on the corn (Karimi and Naderi, 2007).

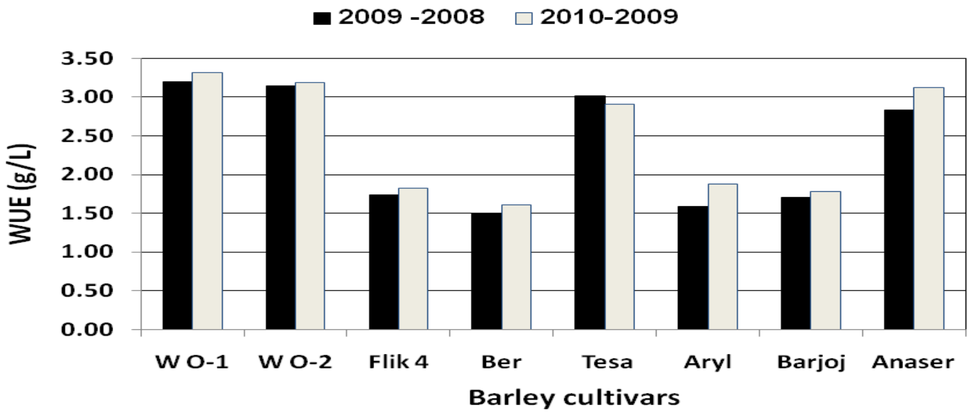

Figure 5. Water use efficiency related to barely cultivars in two seasons.

The interaction between the tested variables salinity levels and barley cultivars had significant effect on WUE (Figure 3). The average of highest WUE values (3.64, 3.58 and 3.59 g L^{-1}) were obtained from WO1 cultivar irrigated with the lower salinity levels (0.35, 2 and 4 dS m^{-1}). Meanwhile, the average lowest WUE (0.64, 0.95 and 0.98 g L^{-1}) were recorded when Aryl, Barj.and Bera. Cultivars, respectively, were irrigated with high salinity levels (10 dS m^{-1}). This result is found to be on line with the finding obtained by Yurtseven et al., (2005). Overall, salinity stress was negatively related to WUE in salinized plants. To the extent that leaf WUE can be used as a surrogate for whole plant growth or yield per water use, increased leaf WUE under salinity stress can be an indicator of tolerance to salinity. This is an important result as it shows that variations in leaf WUE, a potential integrator of growth and water use, can be used as an index of salt tolerance.

CONCLUSION

The results showed that the crop yield and water use efficiency significantly reduced, when the sality level exceed 6 dS m^{-1}. The yield potential of genotypes was a critical importance for the high yield and high WUE. High yield level is provided by the high spike and grain numbers as a genotypic traits, even if saline condition.

REFERENCES

Akman Z. 2009. Effect of GA3 and kinetin pre-sowing treatments on seedling emergence and seedling growth in wheat under salin conditions .J. Anim. Vet. Adv., 8: 362-367.
Allen RG, Pereira LS, Raes D, Smith M. 1998. Crop evapotranspiration guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No.56 united Nations–Food and Agricultural Organization, Roma, Italy.
Andarzian B, Bannayan M, Steduto P, Mazraeh M, Barati ME, Barati MA, Rahnama A. 2011. Validation and testing of the AquaCrop model under full and deficit irrigated wheat production in Iran, *Agricultural Water Management* (100) 1–8.
Ashraf M. 2004. Some important physiological selection criteria for salt tolerance in plants. Flora. 199, 361-376.
Ashraf M., Foolad M. 2013. Crop breeding for salt tolerance in the era of molecular markers and markerassisted selection. Plant Breeding, 132: 10-20.
Bagci AS, Ekiz H, Yilmaz A. 2007. Salt tolerance of 16 wheat genotypes during seedling growth. Turk. J. Agric. For., 31:363-372.
Chartzoulakis K, Loupassaki M, Bertaki M, Androulakis I . 2002. Effects of NaCl salinity on growth, ion content and CO_2 assimilation rate of six olive cultivars. Scientia Horticulturae 96: 235–247.
Chen Z, Zhou M, Newman I, Mendham N, Zhang G, Shabala S. 2007. Potassium and sodium relations in salinised barley tissues as abasis of differential salt tolerance.Funct. *Plant Biol.* 34, 150–162. doi: 10.1071/FP06237.
ComarA , Zscheile L . 1941. Spectrophotometric method for chlorophyll determination plant physio., 16: 651 and Vol. 17:198.
Croser C, Renault S, Franklin J , Zwiazek J. 2001. The effect of salinity on the emergence and seedling growth of Picea mariana, Picea glauca and Pinus banksiana. *Environ. Pollut,* 115:9-16.
Daneshmand F, Arvin MJ, Kalantari KM. 2010. Physiological responses to NaCl stress in three wild species of potato in vitro. Acta Physiol. Plant 32, 91–101.
El-Karamity AE, Aatta Allah SA . 1997.Response of some maize cultivars to irrigation with drainage water. *Alex. J. Agric. Res*. 42 : 33-45.
FAO. 2007. FAO Agristat, www.fao.org (accessed on 10 June 2010).
Francois LE, Grieve CM, Maas EV, Lesch SM. 1994. Time of salt stress affects growth and yield components of irrigated wheat. Agron. J., 86: 100–7.
Gomez KA , Gomez A. 1984.Statistical Procedures for Agricultural Research. John Wiley and Sons, New York. 2nd ed. 680 P.
Grewal HS .2010.Water uptake, water use efficiency, plant growth and ionic balance of wheat, barley, canola and chickpea plants on a sodic vertosol with variable subsoil NaCl salinity. Agric. Water Manage. 97: 148–156.
Gunes A, Inal A, Alpaslan M, Eraslan F , Bagci EG, Cicek N. 2007. Salicylic acid induced changes on some physiological parameters symptomatic for oxidative stress and mineral nutrition in maize (*Zea mays L.)* grown under salinity. J. Plant Physiol. 164, 728–736.
Innocenti ED, Hafsi C, Guidi L, Navari F .2009. The effect of salinity on photosynthetic activity in potassium – deficient barley species. J. of plant physiology. 66: 1968-1981.

Jensen ME. 1983. Design and Operation of Farm Irrigation Systems. ASAE, Michigan, USA. P827.
Joslyn M A. 1970. Methods in Food Analysis, Physical, Chemical and Instrumental Methods of Analysis. 2nd. A cademic Press, New York and London.
Karimi A , Naderi M. 2007.Yield and water use efficiency of forage corn as influenced by superabsorbent polymer application in soils with different textures, Agricultural Research, 7 (2007) 187-198.
Ochiai K, Matoh T. 2001. Mechanism of salt tolerance in the grass species, Anneurolepidium chinense. I. Growth response to salinity and osmotic adjustment. Soil Sci. Plant Nutrition. 47, 579-585.
Oueslati OM, Ben-Hammouda MH, Ghorbal M, Guezzah R, Kremer J. 2005. Barley Autotoxicity as Influenced by Varietal and Seasonal Variation. Jornal of Agronomy & Crop Science, 191, 249-254.
Parida AK, Das AB. 2004. Salt tolerance and salinity effect on plants: a review. Ecotoxicology and Environmental Safely, 60: 324–349.
Romero-Aranda R, Soria T, Cuartero J.2001.Tomato plant-water uptake and plant-water relationships under saline growth conditions. Plant Sci. 160; 265–272.
Sairam RK, Roa KV, Srivastava GC. 2002. Differential response of wheat cultivar genotypes to long term salinity stress in relation to oxidative stress, antioxidant activity and osmolyte concentration. Plant Sci., 163: 1037–48.
Shahbaz M, Ashraf M . 2013. Improving salinity tolerance in cereals. Crit. Rev. Plant Sci., 32: 237-249.
Subhashini K, Reddy G. 1990. Effect of salt on enzyme activities in callus cultures of tolerant and susceptible rice cultivars. Indian J. Exp. Bio., 28:277-279.
Witzel K,Weidner A, Surabhi GK, Börner A, Mock HP. 2009. Salt stress-induced alterations in the root proteome of barley genotypes with contrasting response towards salinity. J. Exp. Bot., 60: 3545-3557.
Yildirim E,Guvenc I. 2006. Salt tolerance of pepper cultivars during germination and seedling growth. Turk. J. Agric. For., 30:347-353.
Yurtseven E, Kesmez GD, Unlukara A. 2005.The effects of water salinity and potassium levels on yield, fruit quality and water consumption of a native central anatolian tomato species (*Lycopersicon esculantum*). Agric. Water Manage. 78: 128–135.
Zadoks JC, Change TT, Knozak CF. 1974. A decimal code for the growth stages of cereals. Weed Res., 14:415-421.