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Preliminary Assessment of the Effect of Saline Water Used in Irrigation on the Growth of the Local Barley Cultivar (Harma)

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تقييم تمهيدي حول تأثير الماء المالح المستعمل للري على نمو الشعير المحلي (هارمة)

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دُرس تأثير الزيادة التدريجية في ملوحة التربة باستعمال محاليل مخففة من ماء البحر على نمو وإنتاجية نبات الشعير المحلي (هَارمة). لم يستطع هذا الصنف مقاومة الصدمة الازموزية الناجمة عن أكثر من ١٤ ديسي سيمتر / متر (توصيل كهربائي لمستخلص التربة المشبعة)، بينما أظهر نمواً جيداً وأنتج حبوباً عند توصيل كهربائي لمستخلص التربة المشبعة بين ٢٣ إلى ٢٨ ديسي سيمتر / متر، حينما كانت الزيادة في ملوحة التربة تدريجية. تم تحليل نمو الأوراق خلال عملية الزيادة التدريجية لملوحة التربة. أظهرت مساحة الأوراق وعمليات النمو التي تؤثر في تلك المساحة نقصاً متدرجاً مع ملوحة التربة مع إستمرار الري بمياه مالحة. فضلاً عن ذلك، فإن صبغات البناء الضوئي أظهرت هبوطاً كبيراً وخصوصاً كلورفيلات أ و ب، بينما لم تظهر الكاروتينويدات أي تغيرات واضحة مع ملوحة التربة.

أثبتت الدراسة أن صنف الشعير هارمة يبني قدرة متدرجة لمقاومة الملوحة وأنه أكثر تحملاً للملوحة خلال فترة ما بعد التزهير والإنتاجية.

Key Words: Growth processes, Harma barley, Irrigation, Leaf growth, Saline water,Yield

ABSTRACT

The effect of gradual increase in soil salinity, using diluted solutions of seawater, on growth and yield of the local barley cultivar (Harma) was examined. Harma barley did not withstand osmotic shock higher than ECe of 14 dSm-1 , while it permitted better growth and produced grains at ECe of 23 to 28 dSm-1 when achieved by gradual manner. Growth analysis of individual leaves was investigated during the course of gradual increase in the level of soil salinity. Area of leaves and the fundamental growth processes (cell division and cell expansion) affecting the area were decreased as soil salinity increased by continuous irrigation with saline waters. Moreover, photosynthetic pigments showed considerable reduction with salt treatments. However, the main reduction in these pigments was in chlorophylls a and b, while carotenoids showed no consistent changes with salinity.

Harma barley developed gradual potential resistance to salinity and proved to be more salt tolerant during post - flowering and yield formation stages.

INTRODUCTION

Irrigation in arid and semiarid regions of the world faces serious challenges because of the limited supply of high quality irrigation water. In fact, expanding demands for the cultivation of agricultural lands in these regions led to use saline water for irrigation (1). Large quantities of saline water frequently exist as ground and sewage waters. Such waters could be used to supplement high quality irrigation water, and, would not only permit the expansion of irrigated agriculture, but also provides means of partially disposing of saline drainage water (2). Moreover, some plants developed salt resistance when soil salinity was gradually increased by increasing the electrical conductivity of the soil solution (3, 4), leading to the conclusion that saline water can be used in the production of some crops (5), as well as raising their resistance to salinity (6).

On the other hand, Rawda soils in Qatar are quite suitable for agricultural purposes. These areas are not only suffering from water shortage but also facing serious continuous rise of the soluble salts (7), which could reach levels that inhibit plant growth (8, 9) . In fact, the information about the response of cultivated plants in Qatar to soil salinity are scarce. Barley plant has been proved to be salt tolerant crop since 50% yield decrement was achieved by the ECe of 18 dSm-1 of the soil extract at 25 °C under common surface irrigation methods (10, 11). The local barley cultivar (Harma) has been recommended by the Ministry of Municipality and Agriculture of the state of Qatar, and proved to be successful cultivar and superior over other cultivars under climatic conditions in the Arab Gulf region (12). Therefore, this study was undertaken to assess the effect of gradual increment in soil salinity on growth, yield and some physiological aspects of this cultivar.

Materials and Methods

Plant material and soil :

Seeds of Harma barley (Hordeum vulgare L.) were obtained from the Department of Field Crop Research, Administration of Agriculture and Water Research, Ministry of Municipality and Agriculture, Qatar, in October 1998. The viability test for these seeds showed that 96 to 98% of the seeds were viable.

The soil, a sandy clay loam, used in the study was obtained from the university area, mixed thoroughly with some artificial clay. The mixed soil was dried, cleaned, homogenized and sieved. The sieving process was done with a sieve of mesh 2 mm in diameter. Some of the characteristics of the soil used in the current study are listed in Table (1).

Growth conditions :

Seeds were germinated in Petridishes upon two layers of filter paper moistened with some water. After five days, the germinated seeds produced coleoptiles of about 1 cm in length. Seedlings were transferred to pots of 14 cm. in diameter and 14 cm. in depth, each holding about 2 kg. dry soil. Table (2) shows the salinity treatments applied to barley plants. All treatments were replicated three times and the replicates distributed randomly inside the glasshouse.

Seedlings were thinned to 6 per pot after one week of the transfer to the soil. The experiments were conducted during the period March to May 1999 under natural conditions. The glasshouse was cooled by central cooling system to maintain the temperature in the range 23 to 33°C. The water content of the soil was maintained to the specified field capacity by adding tap water or saline water as specified in Table

(2) every two days to hold pots at their original weight. After six weeks of treatments all plants were irrigated by tap water till the end of the season.

Experiments of 2000 :

The same experiments were repeated during the period March to May 2000. The temperatures in the glasshouse ranged between 26 to 36°C, and the final ECe of soil extracts was determined. The outcome of these experiments was almost similar to that of 1999. Also, the salinized soils used in the experiments of 1999 were used to study the effect of salt stress (osmotic shock) on growth of barley plants during the season of 2000.

Measurements :

Leaf growth :

The area of individual leaves (3,4 and 5) and the remaining leaves on the main stem were determined according to the method described by Watson (13) and has been used and recommended by many authors (14, 15, 16). Fresh weight was converted to area according to the following formula:

$$\text{Area (cm)} = 66.5 \times \text{FW (g)}$$

Cell number and volume:

The number and volume of cells were determined according to the method described by Sunderland (17). Cells were counted using double chambered Hawksley haemocytometer slide. The cell volume was estimated by the formula:

$$\text{Cell volume} = \frac{\text{Fresh mass / Cell density}}{\text{Cell number}}$$

assuming that the cell density is equal to the density of water.

Chloroplast pigments :

Chlorophylls a and b and carotenoids were determined according to the method recommended by Metzner et al. (18). The determination of these pigments was done for fully expanded leaves after 40 days from the transfer of seedlings to the soil.

Yield :

Plants were harvested at the end of may 1999 and the weight of 1000 seeds were determined.

RESULTS AND DISCUSSION

The general feature of plants exposed to osmotic shock versus those growing in soil of the same electrical conductivities of the soil extracts, achieved by gradual increased in the salinity levels, are shown in Figure (1). These features have revealed that Harma barley did not withstand osmotic shock higher than ECe of 14 dSm-1 , while this cultivar permitted better growth and even produced grains at ECe 28 dSm-1 when achieved by gradual manner (Figures 2 and 3). The total leaf area, on the other hand, was reduced to 35% at ECe of 14 dSm-1 by osmotic shock (Data are not shown), while area of leaves was reduced to about 61% at ECe of 23 to 28 dSm-1 by gradual increase in the soil salinity (Table 3). These data clearly indicated that Harma barley develop gradual potential resistance to salinity. Similar results were obtained in many crop plants. For example, cotton plants developed salt resistance when the NaCl content of the soil was gradually increased by raising the electrical conductivity of the soil solution 2 dSm-1 every two weeks (3). Moreover, irrigation with salt solutions increased the tolerance of many crops as reported by many authors (4).

The data of grain yield, on the other hand, were not comparable to those of total leaf area because yield was reduced to about 74% at ECe of 23 to 28 dSm- (Table 3). The considerable differences between vegetative growth and productivity could be explained by the fact that barley plant proved to be more resistance to salinity and drought at post - flowering stage (15, 19, 20).

Growth analysis of individual leaves (third, fourth and fifth) of the main stem was studied during the course of the gradual increased in the level of soil salinity. The mean time of emergence of these leaves showed considerable differences due to salt treatment. For example, leaf 3 was emerged almost at the same time under all salt treatments (Table 4), whereas those treatments had significant retarding influence on the mean time of emergence in leaves 4 and 5. Therefore, leaf 3 was not affected by salt stress, while both fourth and fifth leaves were delayed in their emergence due to the considerable accumulation of salts after three weeks of irrigation with saline waters.

Area of leaves and the fundamental growth processes affecting the area were investigated. Table 5 shows that area of leaf 3 was not significantly affecting by salt treatment since it started to appear after about two weeks (Tables 2 and 4) during which no much salts were accumulated by irrigation with saline waters. Other individual leaves, on the other hand, showed substantial reduction in their areas because considerable amounts of salts were accumulated after 3 to 4 weeks of irrigation. Area of leaf 5 was further reduced by salt treatment as compared to leaf 4 (Table 5). The reduction in leaf area by salt treatments can be explained by the reductions in number and / or volume of cells (21, 22). The growth processes seemed adversely affected by saline irrigation, however, the effect was not significant in leaf 3, whereas the effect was highly significant in leaves 4 and 5 as shown in Tables 6 and 7. The salinity levels that caused 50% in the leaf area was higher than 14 dSm-1 for leaf 4, while area of leaf 5 was reduced 50% exactly at 14 dSm-1 .

The data of the total photosynthetic pigments (Table 8) showed clearly that increasing soil salinity caused considerable reduction ($p < 0.05$), however, the main reduction in these pigments were due to decreasing the contents of chlorophyll a and b, while the carotenoid contents were not consistent with increasing soil salinity. This finding was generally in accordance with previous reports of many workers on various plant species (16, 23, 24). The adverse effect of osmotic stress due to salinity on photosynthetic pigments can be attributed to the inhibition of the pigment biosynthesis or degradation of the synthesized pigments by increasing the activity of chlorophyllase enzyme (25) as well as damaging the lamellar system of chloroplasts (21).

Finally, it can be concluded from these data that gradual accumulation of salts in the soil caused further reductions in the growth parameters and other physiological aspects of leaves that emerged latter in the season, and

Harma barley seemed more tolerant to osmotic stress at yield formation stages.

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Table (1)

Chemical and physical properties of the soil

Properties	Values
PH (water extract)	7.4
Sat. Ext. ECe (dSm^{-1})	2.2
Field Capacity %	35
Clay (g Kg-1 dry soil)	220
Silt (g Kg-1 dry soil)	130
Sand (g Kg-1 dry soil)	650

Table (2)

The treatments applied to barley plants (Harma cultivar) after transferring the seedlings to soil

Salinity Treatments	Weeks						Final
	First	Second	Third	Fourth	Fifth	Sixth	ECe dSm-1
T0	Tap Water	Tap Water	Tap Water	Tap Water	Tap Water	Tap Water	**4**
T1	Tap Water	10% SW	10% SW	10% SW	10% SW	10% SW	**14**
T2	Tap Water	10% SW	20% SW	20%SW	20% SW	20% SW	**18**
T3	Tap Water	10% SW	20% SW	30% SW	30% SW	30% SW	**23**
T4	Tap Water	10% SW	20% SW	30%SW	40%SW	40% SW	**28**

SW = Seawater collected from Doha coast

10% SW = 6.9 dSm^{-1}

20% SW = 13.0 dSm^{-1}

30% SW = 19.4 dSm^{-1}

40% SW = 27.4 dSm^{-1}

Table (3)

The effect of soil salinity on the total leaf area (after 40 days from the transfer of seedlings to the soil) and yield of Harma barley

(Figures in parenthesis indicate percentage of control)

Salinity treatments	Toatal leaf area (cm2 plant -1)	– S.D.	Weight of 1000 seeds (g)	– S.D.
T0	76.7 (100)	6.9	46.8 (100)	1.9
T1	64.3 (84)	7.6	41.1 (88)	4.8
T2	51.6 (77)	4.2	36.0 (67)	2.1
T3	45.4 (59)	4.4	36.6 (78)	1.5
T4	47.4 (62)	6.8	32.5 (69)	1.9

Tratments : $p < 0.01$: $p < 0.01$

Table (4)

The mean time of emergence (days) of individual leaves on the main stem after transferring the seedlings of Harma barley to the soil

Salinity treatments	Leaf 3	– S.D.	Leaf 4	– S.D.	Leaf 5	– S.D.
T0	15.0	1.0	23.7	1.5	30.7	1.5
T1	14.3	1.5	25.0	1.0	33.3	1.5
T2	15.7	0.6	26.0	1.0	36.0	1.0
T3	16.0	1.0	31.0	2.0	41.7	1.5
T4	14.3	1.2	31.7	1.5	42.3	1.5

Table (5)

The effect of soil salinity on the area of individual leaves (cm^2 $leaf^{-1}$), fully expanded, of barley cultivar Harma

Salinity treatments	Leaf 3	– S.D.	Leaf 4	– S.D.	Leaf 5	– S.D.
T0	18.3	1.0	23.1	5.5	18.0	2.2
T1	19.2	3.5	16.8	0.9	9.1	3.0
T2	17.7	1.0	10.7	1.5	5.3	1.4
T3	17.6	0.9	9.2	4.7	2.2	1.5
T4	20.5	3.3	11.1	2.8	2.8	2.0

Treatments : n.s. : $p < 0.01$: $p < 0.001$

Table (6)

The effect of soil salinity on the number of cells (10 6) of the individual leaves (fully expanded) of barley cultivar Harma

Salinity treatments	Leaf 3	– S. D.	Leaf 4	– S.D.	Leaf 5	– S.D.
T0	4.814	0.700	5.823	0.687	4.746	0.592
T1	5.040	0.823	4.464	0.510	3.119	0.692
T2	4.673	0.655	3.502	0.797	2.101	0.216
T3	4.384	0.834	3.684	1.575	1.269	0.251
T4	5.358	0.806	3.724	0.982	1.571	0.699

Tratments : n.s. : $p < 0.05$: $p < 0.001$

Table (7)

The effect of soil salinity on the volume of cells (mm3) of individual leaves (fully expanded) of the barley cultivar Harma

Salinity treatments	Leaf 3	– S.D.	Leaf 4	– S.D.	Leaf 5	– S.D.
T0	61.5	3.6	65.2	4.5	52.3	3.8
T1	62.4	2.7	54.8	3.9	49.4	2.4
T2	60.7	0.9	50.4	1.7	42.8	2.3
T3	63.4	4.1	49.8	4.1	36.6	8.4
T4	58.9	4.5	52.3	2.4	38.1	5.4

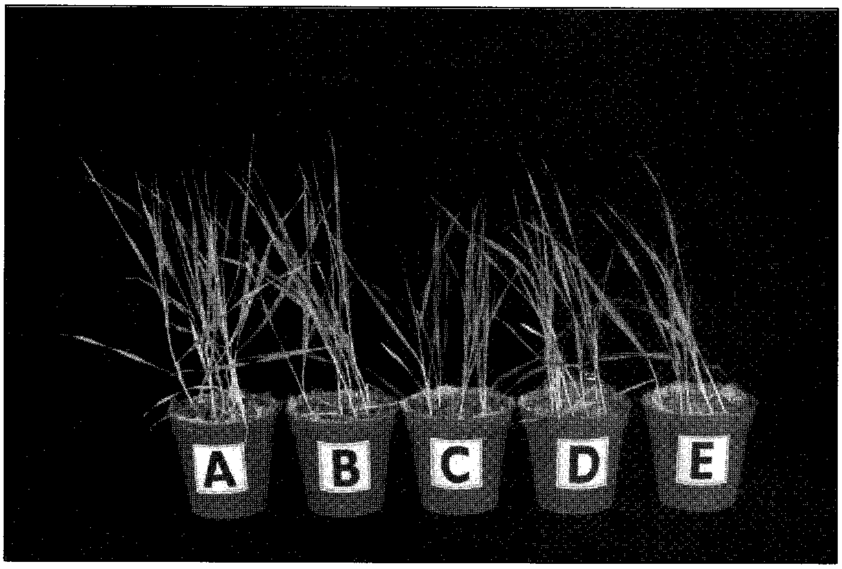
Treatments :n.s. : $p < 0.01$: $p < 0.01$

Table (8)

The effect of soil salinity on the photosynthetic pigment contents (mgg^{-1} FW) of leaves (fully expanded) after 40 days from the transfer of seedlings of Harma barley to the soil

Salinity Treatments	Chl. A	– S.D.	Chl. B	–S.D.	Carotenoids	– S.D.	Total pigments	– S.D.
T0	0.87	0.12	0.53	0.09	0.25	0.07	1.65	0.19
T1	0.92	0.10	0.46	0.04	0.29	0.04	1.67	0.09
T2	0.83	0.09	0.39	0.08	0.29	0.03	1.52	0.18
T3	0.70	0.08	0.36	0.05	0.22	0.01	1.28	0.14
T4	0.58	0.04	0.29	0.03	0.26	0.04	1.13	0.08

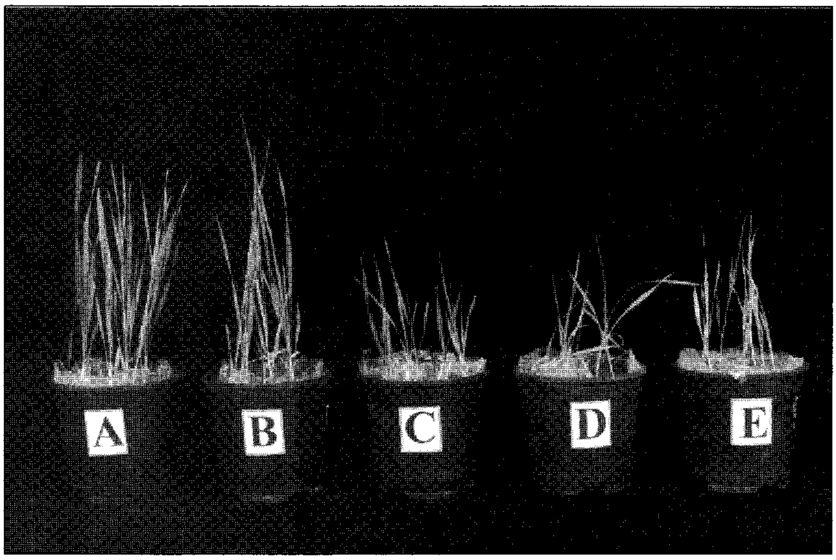
Treatments : $p < 0.05$: $p < 0.05$: n.s. $p < 0.05$



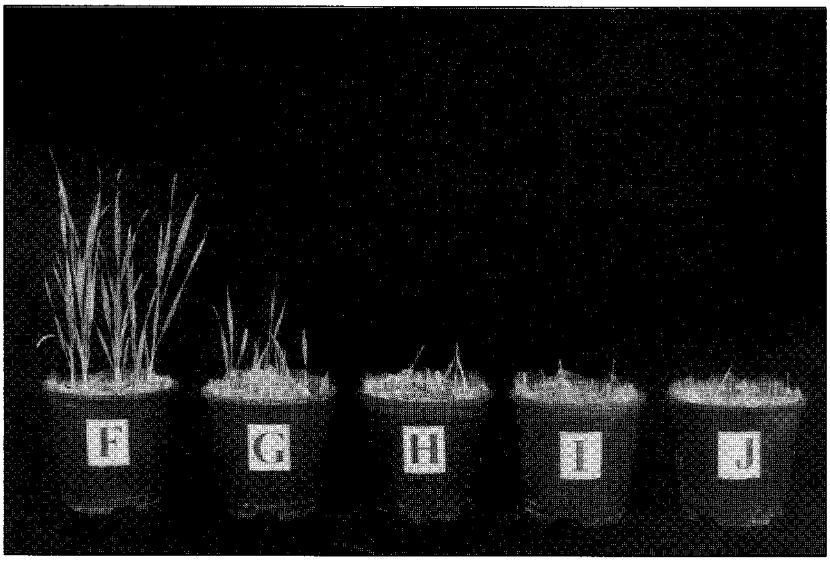
(1)

(1) Experiment of 1999.

(2) Experiment of 2000
(gradual increase in soil salinity)



(2)



(3)

(3) Experiment of 2000 (the salinized soil used in experiment of 1999 was used to study the effect of osmotic shock on growth of Harma barley)

Figure (1)
The general feature of Harma barley plants grown in salinized soils.

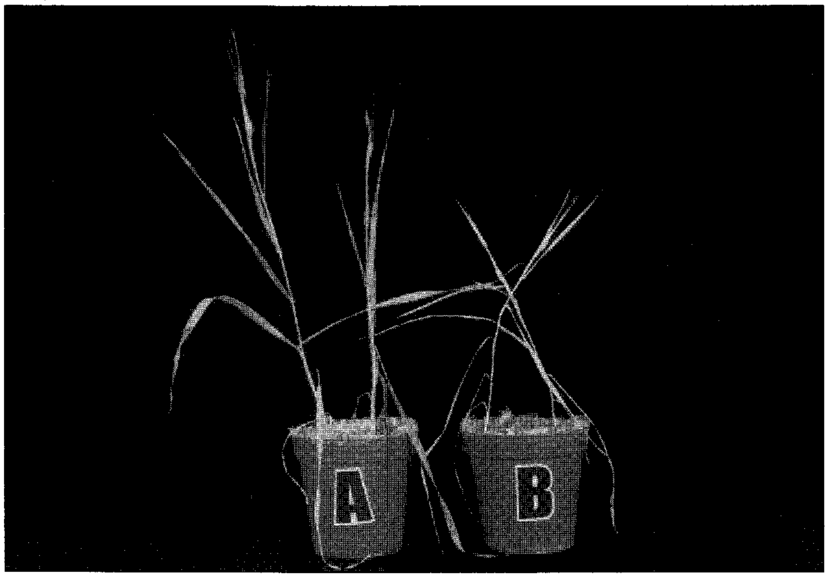


Figure 2

Harma barely plants grown in soil irrigated by:

(A) tap water,

(B) saline water by gradual manner reaching EC3 of 28 dSm^{-1}

(2) **(1)**

Figure (3)

Harma barley produced spikes and grains at 28 dSm-1.

(1) Control,

(2) ECe of 28 dSm-1 (gradual increase in soil salinity)