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ALTERNATIVE OF SALINE AND NON-SALINE IRRIGATION WATER INFLUENCE GROWTH, YIELD AND QUALITY OF CRISP HEAD LETTUCE CULTIVARS UNDER GREENHOUSE CONDITIONS

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ABSTRACT

With increase in demand for irrigation, underground water is becoming scarce and low in quality. The objective of this study was to evaluate the effect of water quality on growth and yield of lettuce cultivars. Two sources of water (well water, EC 4.5 ds.m^{-1}, and desalinized water, EC 0.5 ds.m^{-1}) were applied to irrigate three lettuce cultivars (Sahara, Sharp Shooter and Summer Time). Drip irrigation system was used for six days per week during the winter seasons of 2005and2006 under a greenhouse conditions. Six mixtures of the two irrigation water sources were imposed. These were the irrigation with either sources of water for entire growth season (85 days), irrigation with desalinized water for four days then with well water for two days, irrigation with desalinized water for three days then with well water for three days, irrigation with desalinized water for two days then with well water for four days and irrigation with desalinized water for one day then with well water for five days. Results revealed that head traits (diameter, length and stalk length) and bolting percentage were not affected by water quality except when the plants were irrigated continuously with well water. No significant differences were found in most of lettuce traits when plants were irrigated with three days or more with desalinized water. Significant negative effect of irrigation with well water on yield

and its components occurred when irrigation period was/ or exceeded four days per week. Continuous irrigation with well water significantly reduced total yield by 25 % and 19.8 % and significantly reduced marketable yield by 27 % and 32 % for the first and the second seasons respectively. Significant differences among cultivars were found in most traits. Highest values for total and net marketable yield were recorded for Sahara cultivar followed by Sharp Shooter and Summer Time cultivars. All studied traits of the three cultivars were less affected when lettuce plants irrigated with desalinized and well water of the same period (three days each) and total were yield was only reduced by 6.2 and 7.7 %, at the first and second seasons compared to the continuous irrigation with desalinized water respectively. It is may be concluded that irrigation with desalinized water for three days followed by another three days with well water is recommended for greenhouse lettuce production to reduce the high cost of water desalinization.

Keywords: *Lactuca sativa* L., salinity, water quality, cultivars, desalinized water

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most popular amongst the salad vegetable crops and has high cash value. One of the major factors influencing growth and yield of lettuce is water quality. Lettuce is classified as a moderately sensitive plant to salinity (Ayers and Westcot, 1985, Dehayer and Gordon, 2004). Lettuce is sensitive during the early seedling and at flowering stages (Shannon *et al*., 1983). Iceberg lettuce appears to be more sensitive to salinity at the late than the early growth stage (Pasternak *et al*., 1986). Salinity affects both vegetative growth and head quality.

In arid and semi-arid climates, most of crop water requirements are supplied through irrigation water which normally contains large amounts of dissolved salts. Therefore, salinity control is often considered a major objective of irrigation management (Dehayer and Gordon, 2004). Beside affecting crop yield and soil physical condition, water quality can affect soil fertility and irrigation system performance. Therefore, knowledge of irrigation water quality is critical in understanding the necessary management changes for long-term productivity (Bauder *et al*., 2004). When water resources are limited and the cost of non-saline water becomes high, crops of moderate to high salt tolerance can be irrigated with saline water (Ragab *et al*., 2005). There are two water management strategies to utilize saline water for irrigation. Firstly, blending (mixture of saline with non-saline water at different ratios). Secondly, cyclic (alternative irrigation with saline and non-saline water). The cyclic method, which is used in this paper, was first introduced and tested by Rhoades (1984). Grattan and Oster (2003) discussed methods of utilizing saline water for irrigation under field conditions. Among these methods were sequential use and blending and cyclic use. In practicing the cyclic management, investigators used the good quality water during the sensitive stages of plant growth and the poor quality water during the non-sensitive stages (Chanduvi, 1997; Pasternak and Demalach, 1993; Rhoades, 1997). This method was used to minimize soil salinity when salt sensitive crops are grown. Cyclic management of good quality water with saline water is easier because it dose not need reservoirs for mixing two sources of irrigation water.

Increasing salt tolerance of crops through plant breeding could increase the sustainability of irrigation with low water quality by reducing the need for leaching and allowing the use of poor water quality (Abdel-Gwad *et al*., 2005). Shannon (1980) made selection for salt tolerance in the lettuce cultivar Empire as a mean of decreasing the effects of field variability. In one cycle of screening, successful selections were made for significant improvement in plant fresh weight (frame) or high head to frame ratio. In subsequent studies conducted in greenhouse sand cultures under more controlled conditions, large number of cultivars and plant introductions of *L. sativa* were screened for salt tolerance during early seedling growth stage (Shannon *et al*., 1983; Shannon and McCreight, 1984). Plant introductions of *L. sativa* showed a wider range of salt tolerance and had a higher mean averages salt tolerance than standard cultivars.

The objectives of this study were (a) to determine the effect of cyclic irrigation treatments on growth and yield of crisp head lettuce cultivars, and (b) to evaluate salinity tolerance of lettuce cultivars under cyclic irrigation treatments.

MATERIALS AND METHODS

This study was conducted during the two winter growing seasons of 2005 and 2006 at the Agricultural Research and Experiment Station in Dirab near Riyadh. Soil texture was sandy and the mechanical soil analysis was 84% sand, 8% silt and 8% clay Seeds of three crisp head lettuce cultivars; namely Sahara, Sharp Shooter and Summer Time were sown (on 17 and 20 January 2005 and 2006, respectively) in plastic trays. Four weeks old seedlings, uniform in size, were transplanted into soil in the fiberglass greenhouse. Two kinds of irrigation waters; I: well water (saline water) with EC 4.5 $dS.m^{-1}$ II: desalinized water (non-saline water) with EC 0.5 $ds.m^{-1}$ were used. The chemical analysis of both irrigation waters is shown in Table (1).

Table 1. Chemical analysis of the two sources of irrigation water:

Characteristics	Well water (saline)	Desalinized water (non saline)
EC ($dS\ m^{-1}$)	4.5	0.5
pH	7.4	6.8
Ca^{++} $meql^{-1}$	11.0	0.73
Mg^{++} $meql^{-1}$	10.5	0.16
Na^{+} $meql^{-1}$	14.65	3.5
K^{+} $meq1^{-1}$	0.56	0.1
HCO_3^{---} $meql^{-1}$	4.7	0.325
Cl^{-} $meql^{-1}$	12.9	1.85
$No3^{-}$ ppm	5.2	2.69
SO_4^{--} $meql^{-1}$	14.61	0.9
SAR	4.66	5.11

Drip irrigation system was applied six days per week using cyclic water management strategy by alternative use of the two kinds of water (saline and non-saline). Irrigation water treatments started 5 days after transplanting. Six water irrigation treatments were applied; (T1) irrigation with desalinized water for the whole growth period (control treatment), (T2) irrigation with desalinized water for four days and with well water for two days, (T3) irrigation with desalinized water for three days and with well water for three days, (T4) irrigation with desalinized water for two days and with well water for four days, (T5) irrigation with desalinized water for one day and with well water for five days, and (T6) irrigation with well water for the whole growth period.

The experimental layout was split-plot system in randomized complete block design with four replications. The experimental units consisted of 18 treatments (six irrigation water treatments and three cultivars). Irrigation treatments were randomly allocated to the main plots while cultivars were arranged in the sub-plots. Plot area was 4 m^2 and included 32 plants. Planting distance was 25 cm and 50 cm between plants and rows, respectively. Temperature and relative humidity were averaged about 22 ± 0.5 $^{\circ}C$ and 80 ± 1.5 % during growth stages, respectively. Fertilization and other cultural practices, such as pest control were applied as commonly recommended in commercial production of greenhouse lettuce (Yamaguchi, 1983).

Eighty days after starting the irrigation treatments, yield of crisp head lettuce of each sup-plot was harvested and weighed with and without outer leaves then converted into kg m^{-2} to determine total and net (marketable) yield. Ten heads were randomly selected from each treatment to measure the following traits: head diameter and length, stalk length, bolting %, leaf dry mater %, average head weight, number and weight of outer leaves.

Data were statistically analyzed using Statistical Analysis System (SAS) and treatment means were compared by using L.S.D. test at 0.05 level according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Effects of cyclic irrigation water treatments:

Head traits of lettuce plants as expressed by; diameter, length and stalk length; were not affected by irrigation treatments, except when irrigated continuously with well (saline) water (Table 2). The trend was, generally, similar in 2005 and 2006 seasons. Progressive decrease in average head weight occurred as a result of increasing irrigation period with well water. However, the significant negative effect occurred only when irrigation period by using well water was exceeded three days per week.

Table 2. Influence of cyclic irrigation treatments of saline and non-saline water on head traits of crisp head lettuce during the winter seasons of 2005 and 2006 under greenhouse conditions.

Irrigation* Treatments	Head diameter (cm)	Head length (cm)	Head weight (g)	Stalk length (cm)
		2005		
T1	10.11a**	12.47 a	612.3 a	5.84ab
T2	09.64ab	12.75 a	584.7 a	5.97a
T3	09.93a	12.35 a	574.3 ab	6.13a
T4	09.78ab	11.96 a	520.4 b	5.05ab
T5	09.65ab	12.53 a	492.9 bc	5.25ab
T6	09.33b	12.21 a	459.2 c	4.65b
		2006		
T1	8.95a	14.21ab	599.8 a	4.92 a
T2	8.58a	14.87a	575.0 ab	5.01 a
T3	8.81a	14.66a	553.6 ab	4.53 a
T4	8.06b	13.36b	537.2 ab	5.30 a
T5	7.76b	14.03ab	523.9 bc	5.45 a
T6	8.03b	13.17b	480.9 c	5.29 a

*T1 = irrigation with desalinized water for the whole growth period
T2 = irrigation with desalinized water for four days and with well water for two days
T3 = irrigation with desalinized water for three days and with well water for three days
T4 = irrigation with desalinized water for two days and with well water for four days
T5 = irrigation with desalinized water for one day and with well water for five days
T6 = irrigation with well water for the whole growth period
**Values followed by the same letter(s) through a particular column of means are not significantly different.

Both weight and number of outer leaves were significantly reduced as period of irrigation with saline water increased (Table 3).

Table 3. Influence of cyclic irrigation treatments of saline and non-saline water on outer leaf, leaf dry matter percentage and bolting traits of crisp head lettuce during the winter seasons of 2005 and 2006 under greenhouse conditions.

Irrigation water Treatments*	Outer leaf weight (g)	No. of Outer leaves	Bolting (%)	Leaf DM (%)
		2005		
T1	127.5 c**	5.6 ab	33.30ab	8.33 a
T2	138.6 bc	5.9 a	42.18a	8.49 a
T3	171.8 a	5.6 ab	28.60bc	8.99 a
T4	152.3 b	5.4 ab	28.60bc	8.86 a
T5	129.3 c	5.1 b	20.30c	8.33 a
T6	105.2 d	5.3 ab	20.30c	8.79 a
		2006		
T1	121.0 d	6.7 d	20.01 a	7.83 a
T2	127.3 d	7.7 bc	24.34 a	7.97 a
T3	154.3 c	7.5 bcd	16.09 a	8.47 a
T4	172.8 b	6.9 cd	26.74 a	8.36 a
T5	194.6 a	8.5 a	17.04 a	7.83 a
T6	190.4 a	8.1 ab	21.70 a	8.38 a

* and ** See footnote of Table 2.

Also, irrigation with saline water more than three days per week adversely affected bolting percentage. However, irrigation treatments did not have any significant effects on leaf dry matter percentage. The cause of reduction of growth under salinity is a matter of controversy. It has been related either to salt-induced disturbance of water balance or to a loss of leaf turgor, which can reduce leaf expansion and so photosynthetic leaf area (Shannon and Grieve 1999). Water stress is considered as one of the most important effects induced by salinity. Reduction of plant water uptake with salinity could be related to reductions in morphological and/or physiological parameters like outer leaf weight and number.

The successive increases in irrigation period with saline water led to successive decrease in total and marketable yield per square meter (Fig. 1 and 2). However, the significant reduction in both traits occurred only when irrigation period exceeded three days per week. Continuous irrigation with well water significantly reduced total yield by 25 % and 19.8 % in the first and second seasons, respectively, and significantly reduced marketable yield by 27 % and 32 % in the first and second seasons, respectively. All studied traits were less affected in T3 treatment (irrigation with desalinized and well water for three days each). The T3 treatment resulted in only 6.2 and 7.7 % reduction of total yield in both seasons, respectively as compared to T1 treatment (continuous irrigation with desalinized water). Generally, the reduction in total or marketable yield when lettuce was irrigated with saline water reflected the decrease in head traits as previously mentioned in table 2 and 3. These results support the finding of Cuartero and Fernandez-Munoz (1999), on tomato, who reported that even under normal growing conditions EC of the root solution, is close to the threshold for yield reduction. Large haulm size coupled with efficient absorption of nutrients may have promoted photosynthesis and hence accelerated increase in head weight. However, increasing salinity affects growth mainly by (a) increased osmotic potential of the soil solution which makes soil water less available for plants, and (b) specific effects of some elements (Na, Cl, B, etc.) present in excess concentrations (Yamaguchi and Blumwald, 2005; Munns, 2005). Other investigators reported significant negative effects in lettuce yield as a result of irrigation with saline water (Shannon *et al*., 1983, Ayers and Westcot 1985, Martin *et al*., 1999, Dehayer and Gordon 2004 and Andriolo *et al*., 2005).

Response of cultivars to cyclic irrigation water treatments:

Significant differences were found among lettuce cultivars in all studied traits, except for number of outer leaves in both seasons and for head and stalk length in the second season. The cultivar Sahara had significantly the highest head diameter, length and weight (Table 4).

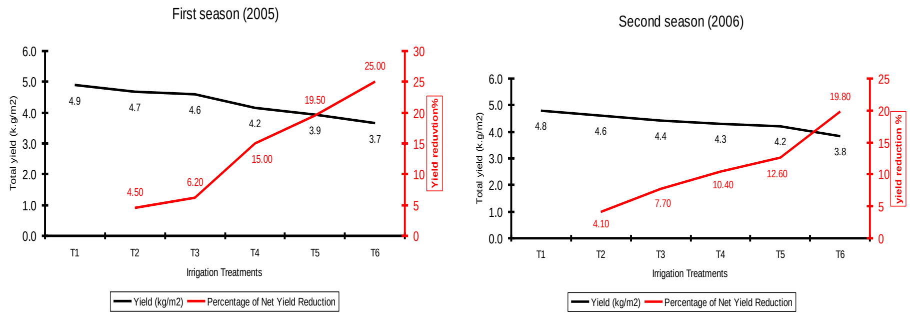

Fig. 1 Influence of cyclic irrigation treatments of saline and non-saline water on total yield and the corresponding percentage reduction during the winter seasons of 2005 and 2006 under greenhouse conditions.

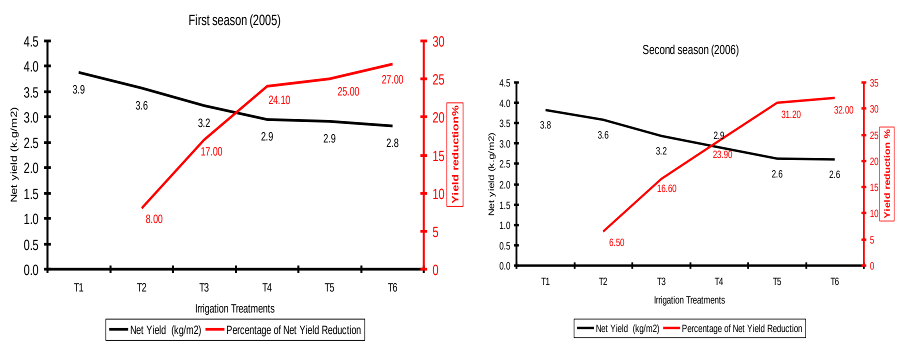

Fig. 2 Influence of cyclic irrigation treatments of saline and non-saline water on marketable (net) yield and the corresponding percentage reduction during the winter seasons of 2005 and 2006 under greenhouse conditions.

However, no significant differences were found between Sharp Shooter and Summer Time for the three traits, except for head diameter and length which were higher in Summer Time in 2005. Sharp Shooter had the highest stalk length followed by Sahara and Summer Time, in the first season, while no significant differences were observed among them in the second season.

Table 4. Head traits of crisp head lettuce cultivars as influence by cyclic irrigation treatments of saline and non-saline water during the winter seasons of 2005 and 2006 under greenhouse conditions.

Cultivars	Head diameter (cm)	Head length (cm)	Head weight (g)	Stalk length (cm)
			2005	
Sahara	10.67a*	12.97a	634.2 a	4.74b
Sharp Shooter	08.93c	12.40b	480.1 b	7.15a
Summer time	09.62b	11.77c	507.7 b	4.56b
			2006	
Sahara	8.71a	14.31 a	637.9 a	4.79 a
Sharp Shooter	8.27b	13.90 a	483.7 b	5.36 a
Summer time	8.12b	13.94 a	513.6 b	5.11 a

*Values followed by the same letter (s) through a particular column of means are not significantly different.

Table 5. Quality traits of crisp head lettuce cultivars as influence by cyclic irrigation treatments of saline and non-saline water during 2005 and 2006 seasons under greenhouse conditions.

Cultivars	Outer leaf weight (g)	No. of Outer leaves.	Bolting (%)	Leaf DM (%)
			2005	
Sahara	143.8 a*	5.64 a	7.03c	8.32b
Sharp Shooter	135.8 b	5.46 a	47.13a	9.01a
Summer time	132.7 b	5.42 a	32.55b	8.56a8
			2006	
Sahara	184.9 a	7.90 a	15.83b	7.68b
Sharp Shooter	136.8 c	7.20 a	19.89ab	8.53a
Summer time	158.5 b	7.50 a	27.24a	8.08a

*Values followed by the same letter (s) through a particular column of means are not significantly different.

Sahara, significantly, had the highest outer leaf weight, followed by Summer Time and Sharp Shooter (Table 5). However no significant differences were observed among the three cultivars for number of outer leaves and leaf dry matter percentage. In the case of bolting percentage, the cultivar Sharp Shooter exhibited the highest value followed by Summer Time and Sahara.

Sahara significantly had the highest total yield per square meter (Table 6). However, no significant differences were observed between Summer Time and Sharp Shooter. In the first season, Sahara significantly had the highest marketable yield, while in the second season no significant differences in marketable yield were found between Sahara and Summer Time. This result was due to increased outer leaf weight for cultivar Sahara compared with the other two tested cultivars. Therefore, marketable yield percentage was lower in Sahara (64.1 %) than in Summer Time and Sharp Shooter (77.4 and 73.4 % respectively).

Table 6. Total and marketable yield of crisp head lettuce cultivars as influence by cyclic irrigation treatments of saline and non-saline water during the winter seasons of 2005 and 2006 under greenhouse conditions.

Cultivars	Total yield (kg/m^{-2})	Marketable yield (kg/m^{-2})
	2005	
Sahara	5.073 a	3.922 a
Sharp Shooter	3.840 b	2.753 b
Summer time	4.061 b	2.999 b
	2006	
Sahara	5.103 a	3.669 a
Sharp Shooter	3.869 b	2.653 b
Summer time	4.108 b	3.056 ab

*Values followed by the same letter (s) through a particular column of means are not significantly different.

The general performances of the three crisp head lettuce cultivars to cyclic irrigation water treatments with saline and non-saline water indicated that the cultivar Sahara was more tolerant to salinity than Summer Time and Sharp Shooter. The response of lettuce cultivars to water quality (salinity treatments) reported in this study was in partial accordance with those reported by Shannon *at al*., (1983) who conducted screening tests for salt tolerance in lettuce using six cultivars and breeding lines. They reported significant variation in salt tolerance existed among cultivars. Their results provided guidelines for the selection of salt tolerant lettuce cultivars.

Interaction effects between irrigation water treatments and lettuce cultivars:

The interactions between irrigation water treatments and lettuce cultivars had only significant influences on average head weight, outer leaf weight, total yield and marketable yield, in both seasons (Table 7). The highest mean values for average head weight, total and marketable yield at the two seasons were attained in Sahara cultivar which irrigated continuously with non-saline water (T1). However, the lowest mean values for the three traits were obtained from the combined treatment which included the cultivar Sharp Shooter irrigated with saline water for the entire season (T6). The combined treatment which included the cultivar Sahara and irrigated with T6 had the highest outer leaves weight, however the lowest value was attained by Sahara cultivar which was irrigated continuously with non-saline water (T1).

The interaction results indicated that T3 was the most efficient treatment for average head weight and total yield per square meter for the three studied cultivars. Results, clearly, indicated that Sahara cultivar showed good performances for average head weight and total yield under all irrigation treatments. However, plants of the Sharp Shooter cultivar reflected good performance only under T1 treatment. Therefore extreme yield reduction occurred when the plants of this cultivar was irrigated with other irrigation treatments. On the other hand, The plants of Summer cultivar Time reflected intermediate means of all studied

Table 7. Interaction effects between cyclic irrigation treatments and crisp head lettuce cultivars on average head weight, outer leaf weight, total and marketable yield during the winter seasons of 2005 and 2006 under greenhouse conditions.

Irrigation* Treatments	Cultivars	head weight (g)		Outer leaf weight (g)		Total yield (kg. m^{-2})		Marketable yield(kg. m^{-2})	
		2005	2006	2005	2006	2005	2006	2005	2006
T1	Sahara Sharp Shooter Summer time	7265.5 a** 545.6 cde 564.8 cd	696.2 a 575.7 bc 527.5 bcd	115.3 efg 126.5 d-g 140.6 c-f	110.3 h 122.7 h 130.1 gh	5.812 a 4.365 bf 4.518 b-e	5.570 ab 4.606 a-e 4.220 c-e	4.980 a 3.353 cde 3.394 cd	4.688 a 3.624 bcd 3.180 def
T2	Sahara Sharp Shooter Summer time	680.2 ab 510.3 def 563.6 cd	675.9 a 548.2 bcd 500.9 cde	133.5 d-g 150.2 b-e 132.3 d-g	126.4 gh 144.2 e-h 111.4 h	5.442 ab 4.082 c-h 4.581 bcd	5.407 abc 4.386 b-e 4.007 def	4.373 ab 2.881 de 3.451 cd	4.396 ab 3.232 de 3.116 d-g
T3	Sahara Sharp Shooter Summer time	71.4 a 494.0 d-g 513.def	715.9 a 451.5 de 493.4 cde	190.2 a 145.2 b-e 180.0 ab	183.8 cde 127.6 gh 151.4 d-h	5.723 a 3.952 c-h 4.108 c-f	5.727 a 3.612 ef 3.947 def	4.202 abc 2.790 def 2.668 def	4.257 abc 2.592 e-i 2.736 d-i
T4	Sahara Sharp Shooter Summer time	618.4 bc 460.0 efg 482.8 d-g	620.3 ab 454.5 de 536.7 bcd	177.5 abc 161.2 a-d 118.2 efg	203.5 bc 179.6 c-f 135.2 fgh	4.947 abc 3.680 def 3.862 c-f	4.962 a-d 3.636 ef 4.293 c-f	3.527 bcd 2.390 f 2.917 def	3.334 cde 2.199 f-i 3.212 de
T5	Sahara Sharp Shooter Summer time	526.3 de 460.2 efg 492.2 d-g	576.3 bc 457.2 de 538.4 bcd	130.2 d-g 128.6 d-g 129.1 d-g	242.1 b 190.7 cd 151.2 d-h	4.210 c-f 3.681 def 3.938 c-f	4.610 a-e 3.658 ef 4.307 c-f	3.169 def 2.653 def 2.905 def	2.674 d-i 2.132 ghi 3.098 d-g
T6	Sahara Sharp Shooter Summer time	538.2 cde 410.2 g 429.2 fg	543.1 bcd 415.2 e 484.6 cde	116.3 efg 103.2 fg 096.1 g	315.7 a 169.9 c-g 126.4 gh	4.306 c-f 3.282 f 3.434 ef	4.345 b-f 3.322 f 3.877 def	3.169 def 2.456 ef 2.665 def	1.819 i 1.963 hi 2.865 d-h

* and ** See footnote of Table 2

characters (between the other two cultivars) under all irrigation treatments. These results clearly, indicated that the three cultivars have different salinity tolerance. Sahara is considered more salinity tolerant followed by Summer Time then Sharp Shooter.

In conclusion, the best cyclic irrigation water treatment under the condition of this study was the irrigation with non-saline water for three days then followed by another three days with saline water. Total yield reduction was only 6.2 and 7.7 %, at the first and second seasons, respectively and it was accompanied by an acceptable head quality. Therefore, it is recommended to apply this treatment for greenhouse crisp head lettuce production to reduce the high costs of water desalinization while maintaining high yield quantity and quality.

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الملخص العربي

تأثير الري المتبادل لمياه الري المالحة والمحلاة على نمو ومحصول وجودة أصناف الخس المتقصف تحت نظام الزراعة المحمية

عبد الله بن عبد الرحمن السعدون و محمود عبادي وهب الله
قسم الإنتاج النباتي- كلية علوم الأغذية والزراعة- جامعة الملك سعود
ص. ب 2460، الرياض 11451، المملكة العربية السعودية

اجري هذا البحث بهدف دراسة تأثير جودة مياه الري على نمو ومحصول وصفات جودة رؤوس الخس خلال الموسم الشتوي لعامي 2005و2006. تمت الزراعة تحت نظام البيوت المحمية واستخدم نوعان من مياه الري (1) ماء بئر ذو معامل توصيل كهربي $4.5\ ds.m^1$ ، (2) ماء تحليه معامل توصيله الكهربائي $0.5\ ds.m^1$ في ترتيب تعاقبي معين لري ثلاثة أصناف من الخس المتقصف (Sahara , Sharp Shooter ,Summer Time) ، تم إتباع نظام الري بالتنقيط وذلك لمدة ستة أيام في الأسبوع. وقد تم تطبيق ستة معاملات للري ؛(1) : ري بماء تحليه خلال مدة التجربة كلها والتي استغرقت 85 يوم ،(2) : ري بماء تحليه لمدة أربعة أيام وبماء البئر لمدة يومين ،(3) : ري بماء تحليه لمدة ثلاثة أيام وبمثلها بماء البئر، (4): ري بماء تحليه لمدة يومين وبماء البئر لمدة أربعة أيام ، (5): ري بماء تحليه لمدة يوم واحد فقط وبماء البئر لمدة خمسة أيام ،(6): ري بماء البئر خلال مدة التجربة كلها. أوضحت النتائج عدم تأثر صفات الرؤوس (الطول والقطر وطول الساق) والنسبة المئوية للإزهار المبكر بجميع معاملات الري باستثناء المعاملة السادسة حيث عكست تأثيرا سلبيا على جميع هذه الصفات، و لم تظهر فروق معنوية في محتوي الأوراق من المادة الجافة خلال موسمي الدراسة. كما لم تظهر فروق معنوية في المحصول عند استخدام معاملات الري الثلاثة الأولى ، في حين ظهر التأثير المعنوي السالب لاستخدام ماء البئر على صفات المحصول ومكوناته خلال موسمي الدراسة بزيادة عدد أيام الري بماء البئر لأربعة أيام أسبوعيا. ولقد أدى استخدام ماء البئر فقط طوال مدة التجربة بمعدل 6 أيام أسبوعيا إلى حدوث نقص في المحصول الكلي بمقدار 25% و19.8%، و المحصول المسوق 27% و32 % مقارنة بالمعاملة الأولى في الموسم الأول والثاني على الترتيب. ولقد أظهرت النتائج فروق معنوية بين الأصناف الثلاثة تحت الدراسة حيث تفوق الصنف Sahara في صفتي المحصول الكلى والمسوق (بعد إزالة الأوراق الخارجية) يليه الصنف Sharp Shooterوأخيرا الصنف Summer Time. ونظرا لأن المعاملة الثالثة لم تحدث إلا نقصا يسيرا في المحصول الكلي (6.2% و 7.7% في الموسم الأول والثاني على التوالي) فأنه يمكن التوصية بري أصناف الخس تحت ظروف هذه التجربة ثلاثة أيام بماء تحليه وثلاثة أيام بماء البئر بهدف توفير تكاليف تحليه المياه عند إنتاج الخس تحت نظام الزراعة المحمية.