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# Influence of Irrigation with Saline Water on Vegetative Growth and Fruit Yield of Three Greenhouse Cucumber Cultivars

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ABSTRACT. Salt stress and water quality have a severe and determining influencing effects on almost all vegetable crops, especially under the water shed and also the prevailing conditions of the arid zone of the western region in the Kingdom of Saudi Arabia.

Three greenhouse cultivars; Yara, Hayel and Taha were subjected to different salinity stress treatments, simulated through mixing seawater to tap water in the ratio of 5, 10, 15, 20, and 25% by volume.

Increasing the salinity stress, generally, had a reducing and deteriorating effects on seed germination as well as all vegetative growth parameters of the different cucumber cultivars. Irrigation with the saline water, also, immensely reduced number of flowers/plant, fruit setting and crop yield as well as quality measurements. The third order polynomial regression analyses response curves with best fitting also revealed the same trend.

Yara cultivar exhibited the best performance, showing some degree of tolerance, even to severe salinity in some cases, in comparison with Hayl or Taha cultivars.

The overall harmful effects of salinity stresses were most pronounced on the reproductive organs.

KEY WORDS: Salinity, Stress, Sea water, Cucumber cultivars, Irrigation.

## Introduction

Increasing salinity of soils and water constitutes is the principal problem of agriculture in arid and semi arid regions of the world (Epstein *et al.,* 1980). Southwestern Saudi Arabia is an area of great agricultural importance where most intensive horticultural activity concentrated. In this area, as in numerous parts of the country agriculture is seriously threatened by the increasing salinity of the ground water and by the shortage of good quality irrigation water. Irrigation waters are very often saline, with an electrical conductivity (EC) ranging between 2.5 and 5 $dSm^{-1}$. This leading to increasing use of soilless culture of hydroponics under greenhouse conditions. The effect of salinity on a

plant may depend on several environment factors such as reliable humidity (Hoffman *et al.,* 1971), high temperature (Nieman & Poulsen, 1971), light (Ehlig, 1960), and management factors such as irrigation (Bernstein & Hayward, 1958), soil fertility (Nieman & Clark, 1976), and the particular growth of yield (Shannon & Francois, 1978).

The amount and quality of irrigation water available in many of the arid and semiarid regions of the world are the main limiting factors to the extension of agriculture (Beck, 1984). This is particularly true of vegetable crops such as tomato and cucumber which are sensitive to salt (Cerda & Martinez, 1988, and Mitchell & Shennan, 1991). The ability of plants to survive salinity stress is important for natural distribution of plant species and to agriculture (Flowers & Yeo, 1986). The ability of plant to withstand high salt concentrations in the root zone without foliar injury has been used as a test for salt tolerance for several crops (Bernstein & Hayward, 1958). Bernstein *et al.* (1974) also reported that salt tolerance to crop plants has been expressed as yield decrease for a given level of soluble salts in root medium compared with yields under non-saline conditions. High level of salinity significantly reduced growth and had effect on plant morphology (Taleisnik, 1986, and Byari & Al-Maghrabi, 1991).

The plants which were irrigated with saline water showed external signs of chlorosis, leaf burning and poor vegetative development (Gornat *et al.,* 1973; Alder & Wicox, 1987; and Byari & Al-Maghrabi, 1991). Crop yields of tomato have decreased with increasing salinity level of concentration (Adler and Wilcox, 1987; Bolarin & Fernandez, 1991; Papadopoulus, 1984; Byari & Al-Maghrabi, 1991; Mizrahi & Pasternak, 1985; Gornat *et al.,* 1973; Mitchell & Shanan, 1991; Mendlinger and Pasternak, 1992a; Mendlinger and Pasternak, 1992b; and Franco *et al.,* 1997).

Stem elongation, and shoot and root dry weight of tomatoes were reduced under saline irrigation stress (Byari & Al-Maghrabi, 1991; Alder and Wicox, 1987; Shannon *et al.,* 1987 and Meiri *et al.,* 1995). High concentrations of salt reduced and delayed seed germination (Ayers & Hayward, 1948; Nukaya *et al.,* 1979; and Byari & Al-Maghrabi, 1992).

This study was conducted to investigate the effect of irrigation with saline water on three greenhouse cucumber cultivars.

## Materials and Methods

### *Experiment I*

An evaporative cooled greenhouse was used to test the effect of saline water irrigation on three greenhouse cucumber cultivars namely “Hayl”, “Yara”, and “Taha”. This investigation was conducted at King Abdulaziz University Experimental Station in Wadi Hada Al-Sham northeast of Jeddah, Saudi Arabia.

The seed were planted directly in peat cubes in plastic flats. During the germination and early seedling stages, the plants were held in a naturally lighted air conditioned greenhouse at 21-24ºC day and 18-20ºC night and relative humidity 55-65%. Fertilizer rapid growth 20-20-20 was added every 14-16 days from plants emergency until the end

of the experiment. Seedlings were transplanted into plastic pots of 30 cm in diameter containing soil mixture of peatmoss, vermicutile and sand in a 1:1:1 ratio. Salinity treatments were accomplished by mixing seawater and tap water (v/v) as in the following (Tap water, 5%, 10%, 15%, 20% and 25%). These mixtures yielded treatment with E.C. equivalent to 180 ppm (0.28 Mmhose), 2176 ppm (3.4 Mmhose), 4100 ppm (6.41 Mmhose), 5700 ppm (8.91 Mmhose), 7756 ppm (12.12 Mmhose), and 9555 ppm (14.93 Mmhose) respectively. Tap water used as a control. Saline water irrigation treatments were started after 35 days from sowing. The different saline water treatments were applied continuously and gradually to avoid salinity shock on the early stage of plant growth. Plants were watered once a week, with tap water to maintain good drainage and also to ensure leaching accumulative salts and to avoid salt concentration build up and the cumulative effects of the periodical irrigation during the course of the experiment.

Data measurement or counted were recorded for many morphological and physiological characters including plant height, stem diameter, number of leaves/plant, number of flowers/plant, % fruit-set, number of fruits/plant and yield as well as fruit size, fruit diameter and fruit length. The statistical design was a split-plot design. The main plot for water treatments with salts and the subplots for cultivars.

***Experiment II***

The same cucumber cultivars used in experiment I used again to test the effect of saline irrigation water on seed germination of cucumber cultivars. The same different seawater concentration of experiment I were used (Tap water, 5%, 10%, 15%, 20% and 25%). Seeds were sown in plastic flats in a mixture of sand and peatmoss in ratio of 1:1. Boxes were kept in growth chamber at King Abdulaziz University in Jeddah. Room temperatures were 23-26ºC at day and 18-21ºC at night, relative humidity from 50-60% light intensity of 470 UE/$m^{-2}/S^{-1}$ and a photolight 13 hr (automatically controlled) were used. The soil mix (media) was uniformally wetted with the designated solution for each treatment. Moisture need for germination was maintained by periodically for each treatment. Moisture needed for germination was maintained by periodically adding more solution. Germination counts were made after 2 days and were maintained on daily basis thereafter. Counts were done when the cotyledons emerged from media.

## Results and Discussions

It is very obvious that high salt concentration in irrigation water, due to the incremental mixing of seawater, had a strong reducing effects on germination rate and also on all vegetative growth parameters, of the different greenhouse cucumber cultivars, as depicted and illustrated in Table (1) and Fig. (1).

Increasing the salinity level in irrigation water up to 9555 ppm, strongly reduced the germination rate of 45.0% in comparison with the untreated control (180 ppm salinity) which gave 87.5% germination. The rate of reduction due to irrigation with saline water was about 42.5%.

The response of the three cucumber cultivars to salinity treatments was statistically significant. Seeds of Yara cultivars were remarkably tolerant to salinity stresses and

produced 80.4% germination in comparison to either Hayl (65.0%) or Taha (58.8%) cultivars.

TABLE 1. Germination and vegetative growth of three cucumber cultivars as affected by sea water irrigation treatments.

| Treatments | Traits | | | | | |
|---|---|---|---|---|---|---|
| | Germination (%) | Plant height (cm) | Stem diameter (cm) | Leaves number (No.) | Flower number (No.) | Fruit set (5) |
| Salt concentration (ppm) | | | | | | |
| – Tap water (180) | 87.5 a | 215.9 a | 0.64 a | 29.4 a | 24.4 a | 83.30 a |
| – 5% (2176) | 83.3 a | 209.8 b | 0.67 b | 27.0 b | 23.9 a | 84.52 a |
| – 10 % (41100) | 61.6 b | 199.1 c | 0.62 a | 26.0 c | 21.2 b | 78.99 b |
| – 15% (5700) | 69.1 b | 186.8 d | 0.63 a | 24.7 d | 16.6 c | 69.82 c |
| – 20% (7756) | 61.6 b | 174.7 e | 0.60 a | 23.5 e | 15.0 d | 69.82 c |
| – 25% (9555) | 45.0 c | 152.2 f | 0.58 a | 19.8 f | 11.0 e | 38.86 e |
| L.S.D. 0.05 | 11.6 | 2.2 | n.s. | 0.37 | 1.47 | 3.07 |
| Cultivars | | | | | | |
| – Hayl | 65.0 b | 190.7 a | 0.63 a | 25.0 a | 18.5 b | 69.99 ab |
| – Yara | 80.4 a | 190.5 a | 0.60 a | 25.2 a | 19.5 a | 71.87 a |
| – Taha | 58.8 b | 188.5 a | 0.65 a | 25.1 a | 18.2 b | 69.23 b |
| L.S.D. 0.05 | 11.6 | n.s | n.s. | n.s. | 0.99 | 2.10 |

n.s. not significant at the 0.05 level of significance.

The response curve of seed germination (Fig. 1) confirmed and described the strong reducing effect of irrigation with seawater. These results were, also, in general agreement with other investigators' results (Ayers and Hayward, 1948; Ayers, 1953; Nukaya *et al.,* 1979; and Byari and Al-Maghrabi, 1992).

Irrigation with saline water reduced plant height, stem diameter, number of leaves/plant, number of flowers/plant and also reduced the percentage of fruit-setting. This was evident from data presented in Table (1). Increasing the concentration of salt in irrigation water decreased plant height of all greenhouse cucumber cultivars. The highest level of salt (9555 ppm) showed strong influenced on plant height which resulted in stunted plants when compared to other treatments. The reduction in plant height to salinity stresses was significant.

No significant differences were found among the different greenhouse cucumber cultivars in tolerating salinity stresses for plant height. At the same time stem diameter of the three cucumber cultivars was not statistically affected due to the different salinity treatments. It is noticeable, according to the trend of data, as well as research visual observations that there was a gradual tendency for decrease in stem diameter even though no statistical differences were detected.

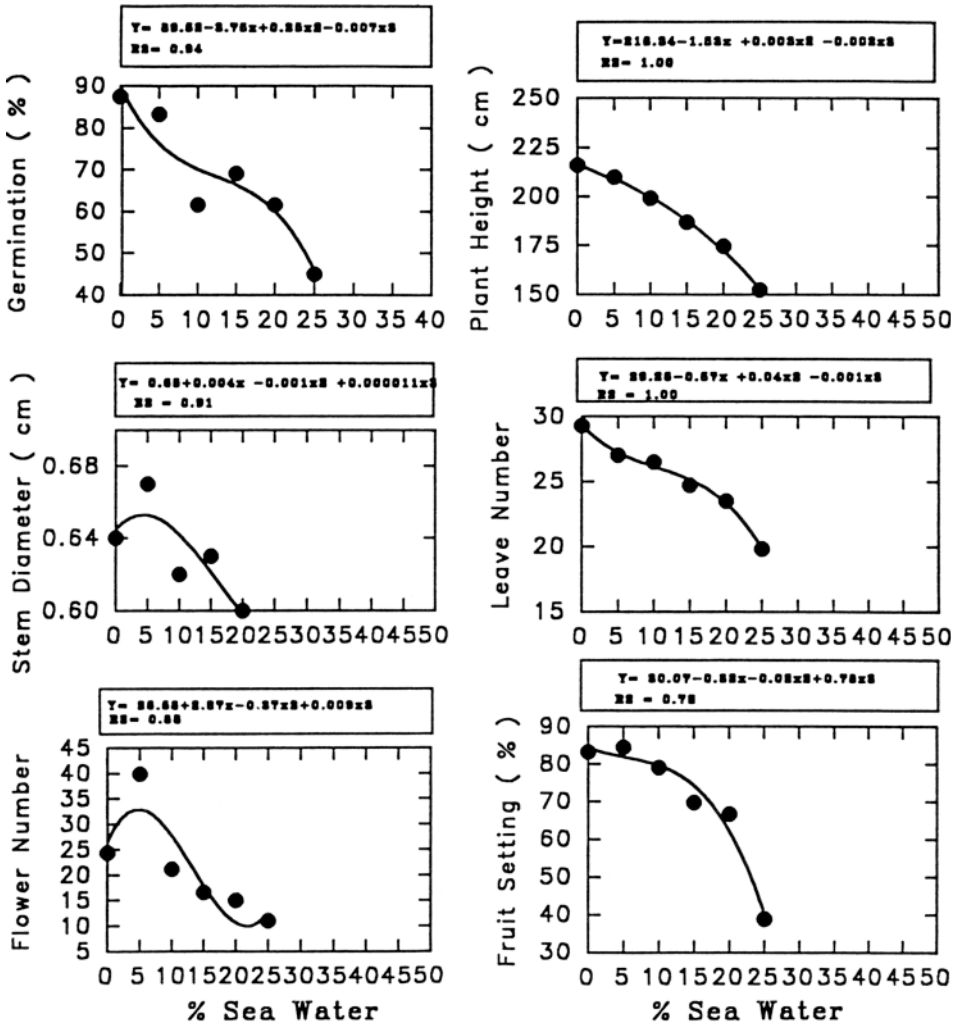


FIG. 1. Third order polynomial regression analyses describing the response curves of seed germination and vegetative growth parameters of three greenhouse cucumber cultivars as affected by sea water irrigation treatments; observed (symbols) and predicted (solid lines).

Stem diameter was not significantly different at tap water (180 ppm) up to 25% seawater (9555 ppm), however, it decreased with increasing the seawater concentrations. Stem diameter was greatest at 5% (2176 ppm) and number of leaves/plant was greatest at tap water (180 ppm). Stem diameter and number of leaves/plant had the least value at 25% (9555 ppm). They were less than tap water in about 9.1% and 32.4% respectively.

No significant differences, among cucumber cultivars, under experiments, were observed concerning stem diameter and number of leaves/plant. Taha cultivar, however, had the largest stem diameter and Yara cultivar had produced the highest number of leaves/plant under stress of irrigation due to saline water. The results indicated that high salt concentrations in irrigation water had minor influence on stem diameter and strong influence on number of leaves/plant of cucumber plants. These results were similar to the results reported by Gornat *et al.,* Taleisnik, 1986; Alder and Wilcox, 1987; Shannon *et al.,* 1987; and Byari and Al-Maghrabi, 1991.

Harmful influences of using seawater in irrigation on the reproductive parts of cucumber plants such as number of flowers/plant and also number of fruits/plant were evident. The highest production of flower/plant was with tap water treatment (control). The reduction in number of flowers/plant was coincidentally significant with increasing the concentrations of seawater from 5 up to 25% in irrigation water. This reduction was equivalent to 2%, 13.1%, 32%, 39.5% and/or 54.9% respectively.

Significant differences were found among cucumber cultivars. Yara produced the highest number of flowers/plant, followed by Hayl. Taha had the least number of flowers/plant. The results indicated that number of flowers/plant was drastically reduced at 25% sea water (9555 ppm), which had direct influencing effects on the number of fruit-set/plant and also on yield. Increasing sea water level reduced the percentage of fruit-set significantly. Significant differences were observed among cucumber cultivars in their ability to set fruit under salinity stresses. Yara cultivar was capable to set fruits in superiority above Hayl or Taha cultivars. The percentage of fruit setting in Yara was 71.87%, meanwhile, it were 69.99 and 69.23% for both the remainder cultivars, respectively. These results were on the same line with other investigators' results (Taleisnik, 1986; Alder and Wilcox, 1987; Byari and Al-Maghrabi, 1991; Bolarin and Fernandez, 1991; and Mitchell and Shannan, 1991; Mendlinger and Pasternak, 1992b; and Meiri *et al.,* 1995). Figure (1) translated the performance of the three greenhouse cucumber cultivars, concerning vegetative growth, into regression response curves with best fitting. The third order polynomial analyses for plant height, stem diameter, leave number, flower number and fruit setting percentage indicated that increasing seawater percentage have damaging, reducing, and deteriorating effects on the overall vegetative growth.

Plant height decreased with increasing seawater concentrations. The highest reduction was with concentration of 9555 ppm. The third order polynomial regression analyses describing the response curve for plant height showed gradual decrease in plant height with increasing seawater level, whereas stem diameter was increased at only 5% (2176 ppm) of sea water concentration and at 10% (4100 ppm) seawater a sharp decrease was occurred and continued decreasing with the increasing of salt levels.

However, the response curve also showed that number of leaves/plant started to decrease with increasing salt levels of seawater. The number of flowers produced per plant initially and treated with 5% seawater (2176 ppm) was reduced and sharply decreased with increasing salinity concentrations in irrigation water. Percentage of fruit-set was also severely affected with increasing salinity concentrations. These results indicated that salinity possibly had an influenced on the fertilization process or it may have an effect on pollen or ovules viability. Further investigations are needed in this regard. Fruit-set was also affected by salinity as well as yield, fruit weight, fruit size, fruit diameter, and fruit length. This was obvious from data presented in Table (2). Number of fruit-set/plant, crop yield, mean fruit weight, fruit size, fruit diameter and fruit length are significantly decreased with increasing seawater concentrations. The number of fruit-set/plant, fruit yield and mean fruit weight as well as fruit size were drastically reduced at 25% (9555 ppm) of sea water.

TABLE 2. Fruit yield and quality of three cucumber cultivars as affected by sea water irrigation treatments.

| Treatments | Traits | | | | | |
|---|---|---|---|---|---|---|
| | Fruit number | Crop yield (kg) | Fruit weight (gm) | Fruit size ($cm^3$) | Fruit diameter (cm) | Fruit length (cm) |
| Salt concentration (ppm) | | | | | | |
| – Tap water (180) | 20.0 a | 3.09 a | 156.7 a | 67.0 a | 2.79 a | 12.11 a |
| – 5% (2176) | 20.2 a | 2.98 a | 146.3 ab | 54.0 b | 2.55 ab | 10.7 b |
| – 10% (41100) | 17.2 a | 2.49 b | 144.3 ab | 50.3 b | 2.51 b | 10.6 bc |
| – 15% (5700) | 11.9 c | 1.36 c | 140.2 b | 48.1 b | 2.58 ab | 9.6 c |
| – 20% (7756) | 10.1 d | 0.84 d | 83.7 c | 49.2 b | 2.47 b | 10.1 bc |
| – 25% (9555) | 6.4 e | 0.38 e | 40.0 d | 28.1 c | 1.61 c | 59.0 d |
| L.S.D. 0.05 | 1.4 | 0.12 | 13.34 | 6.56 | 0.24 | 0.92 |
| Cultivars | | | | | | |
| – Hayl | 13.8 b | 1.83 a | 117.8 a | 45.6 a | 2.39 a | 9.7 a |
| – Yara | 15.1 a | 1.85 a | 118.0 a | 47.4 a | 2.47 a | 9.6 a |
| – Taha | 13.9 b | 1.89 a | 119.7 a | 51.4 a | 2.41 a | 10.2 a |
| L.S.D. 0.05 | 0.9 | n.s. | n.s. | n.s. | n.s. | n.s. |

n.s. not significant at the 0.05 level of significance.

Significant differences were found among cucumber cultivars for their ability in fruit-set under salinity stresses. Yara cultivar showed good ability in fruit-set compared to the other two cultivars under stress. Stress of irrigation with saline water producing the highest number of fruits. However, no significant differences were observed in most of other characters measured or counted such as fruit yield, fruit mean weight, fruit size, fruit diameter and fruit length among cucumber cultivars under investigations. The results were in general agreement of other workers (Gornat *et al.,* 1973; Nukaya *et al.,* 1979; Mizrahi and Pasternak, 1985; Byari and Al-Maghrabi, 1991; Mendlinger and Pasternak, 1992a; Meiri *et al.,* 1995; and Franco *et al.,* 1997).

Figure (2) describes the response curves of number of fruit-set, fruit yield, fruit mean weight, fruit size, fruit length, and fruit diameter of the three greenhouse cucumber cul-

tivars under stress of salinity. The third order polynomial regression analyses ascertain and confirm the way of mean comparison procedure, producing optimum fitting response curves with highly significant regression coefficient with high R2 values. It exhibits the descending, lowering, minimizing, and reducing effects of increasing salinity concentrations through seawater mixing to cucumber.

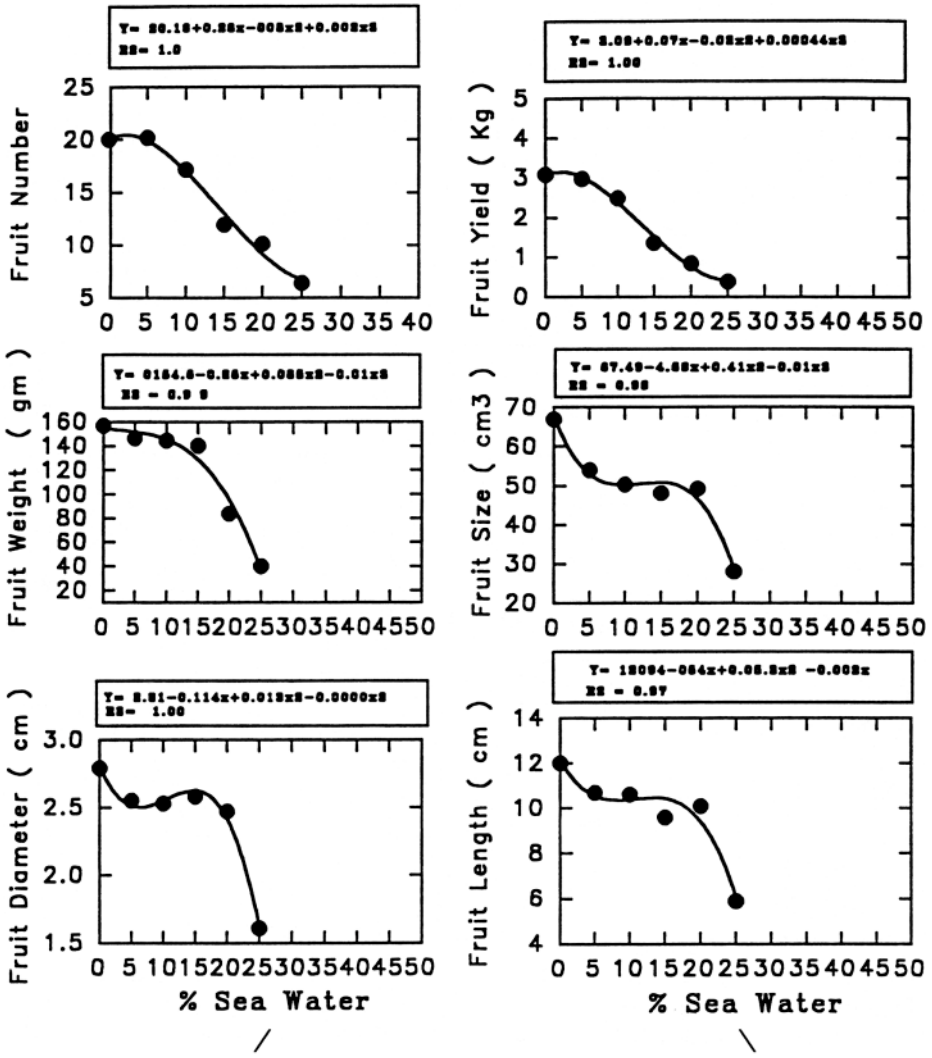


FIG. 2. Third order polynomial regression analyses describing the response curves of fruit yield and fruit qualities measurements of three greenhouse cucumber cultivars as affected by sea water irrigation treatments; observed (symbols) and predicted (solid lines).

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# تأثير الري بالمياه المالحة على النمو الخضري والمحصول الثمري لأصناف خيار البيوت المحمية

**صالح حسين بياري**

*قسم زراعة المناطق الجافة ، كلية الأرصاد والبيئة وزراعة المناطق الجافة*

*جامعة الملك عبد العزيز ، جـــدة – المملكة العربية السعودية*

*المستخلص* . يعتبر الإجهاد الناشئ عن الملوحة ونوعية مياه الري من العوامل المؤثرة والمحددة لنمو جميع محاصيل الخضر تقريبًا ، خاصة تحت تلك الظروف التي تتسم بندرة المياه وشحها وكذلك الظروف السائدة بالمنطقة الغربية للمملكة العربية السعودية .

عرضت ثلاثة أصناف خيار من أصناف البيوت المحمية وهي يارا وحائل وطه إلى إجهادات ملحية عن طريق خلط ماء البحر بماء الصنبور بالنسب ٥، ١٠، ١٥، ٢٠، ٢٥ في المائة بالحجم .

أوضحت النتائج أن زيادة الإجهادات الملحية أدت إلى تأثيرات مثبطة لإنبات البذور والنمو الخضري لأصناف الخيار كلها . كما أدى الري بالماء المالح إلى خفض ملحوظ في عدد الأزهار على النبات ومعدل عقد الثمار وكمية المحصول كما أدى إلى تدهور الصفات التسويقية . كانت التأثيرات السيئة للإجهادات الملحية أكثر وضوحًا على الأعضاء الإنتاجية للنبات . أوضحت أيضًا منحنيات الاستجابة ومعادلات الانحدار من الدرجة الثالثة إلى تأكيد هذه النتائج والحصول على نفس الاتجاه .

أظهر الصنف يارا أفضل نمو تحت ظروف الإجهاد الملحي حتى عند التركيزات العالية وذلك بالمقارنة بباقي الأصناف (حائل وطه) .

كانت التأثيرات الواضحة لإجهادات الملوحة بصفة عامة على الأعضاء التكاثرية للنبات .