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Growth, Yield and Quality of Three Greenhouse Cucumber Cultivars in Relation to Type of Water Applied at Different Stages of Plant Growth

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Abstract

Two levels of salinity in the irrigation water (I: well water with EC 2.61 mmhos/cm, II: desalinized water with EC 0.39 mmhos/cm) were applied to greenhouse cucumber cultivars; Alasil, Alia and Copra; at various stages of growth and for different time duration to study the effect of water salinity on growth, yield and quality in cucumber. Five irrigation treatments (IT) were applied; (IT1) irrigation with desalinized water for the whole experimental period; which was 105 days, (IT2) irrigation with desalinized water until the beginning of flowering stage (30 days) then irrigation with local well water, (IT3) irrigation with desalinized water until the beginning of fruit setting stage (35 days) then irrigation with local well water, (IT4) irrigation with local well water 35 days then irrigation with desalinized water until end of experiment, (IT5) irrigation with well water for the whole experimental period. Vegetative growth traits recorded were: plant height, leaf number, leaf area, leaf fresh and dry weight. Fruit growth traits were; length, diameter, firmness, number, fresh and dry weight. Early and total yield were also recorded. Salinity during the entire growing period (IT5) significantly reduced early and total yield by 46.8 and 28.3 % respectively. Also, it reflected higher negative results in all studied traits, except fruit dry weight. The negative effect of salinity on most traits was less severe when IT4 was applied. No significant differences were found between IT2 and IT3, and they resulted in intermediate negative effect in all studied traits; except for early yield. Significant differences among cultivars were found in fruit growth traits especially yield and its components. Highest value for fruit weight, early and total yield were recorded in Copera followed by Alia and Alasil, respectively. Considering that all traits were less severely affected by IT4 and that total yield was only reduced by 7.2% , as compared to IT1, it can be concluded that the use of salinized irrigation water until fruit setting stage followed by desalinized water for greenhouse cucumber production is recommended to save the high cost of water desalinization.

Keywords: cucumber, Saline irrigation, Water quality, cultivars, yield response, growth stage

Introduction

Cucumber (*cucumis sativus* L.) is one of the main greenhouse crops widely grown in Saudi Arabia. The total greenhouse area for cucumber production increased from 1118 hectares in 1997 up to 2090 hectares in 2001 (Ministry of Agriculture, 2003) and production increased from 67044 ton in 1997 up to 154785 ton. Among all vegetable produced in greenhouse, cucumber production area increased from 20.8% to 72.5% and yield increased from 55.2% to 93.5% respectively. One major factor influencing growth and yield of cucumber is water salinity. Cucumber is moderately sensitive to salinity (Ayers and Westcot, 1985; Dorota, 1997 and Dehayer and Gordon, 2004). Increasing salinity affects growth mainly by reducing the plant ability to absorb water (Hill and Richaid, 1999) and through a reduction in photosynthesis and photosynthesing area (Chartzoulakis, 1994).

In arid and semi-arid climates, where most of the crop water requirement is supplied through irrigation and water often contains large amount of dissolved salts, salinity control is frequently a major objective of irrigation management (Dehayer and Gordon, 2004). Besides affecting crop yield and soil physical condition, irrigation water quality can affect fertility need and irrigation system performance. Therefore, knowledge of irrigation water quality is critical to understanding what management changes are necessary for long-term productivity (Bauder et al., 2004). In many areas of Saudi Arabia, good quality water (low salt and low sodium) is not available for irrigation, consequently waters containing high levels of salt must be used.

Many investigators recorded the negative effects of irrigation with saline water on cucumber growth and yield. According to Al-Harbi et. al. (1995) plant water uptake, growth and yield decreased with salinity. High salinity had a greater effect during the day than during the night indicating that salinity affected water uptake. Abd-Allah et. al. (1992) reported that increasing salinity levels progressively decreased all growth parameters. Increasing salinity (4000 mg Nacl/liter) reduced and delayed germination (Helmy et al., 1994). Growth of cucumber seedlings was generally reduced by increasing salinity. Shoot and root dry weight increased with decreased Na:Ca ratio at 4.0 mg/cm (Al-Harbi, 1994). Folegatti and Blanco (2000) reported that plant height, unit leaf area and leaf area index were linearly affected by water salinity. Fruit growth, fruit number and seed yield per plant decreased with increasing salinity. Plant height, total leaf area, plant dry weight, fruit yield, fruit per plant and fruit weight decreased with increasing salinity, particularly above 1.2 mmohs/cm. Increasing the salinity over 10 Mm Nacl significantly reduced the fruit yield and number of fruits per plant (Chartzoulakis, 1991 and 1994). Cucumber fruits from the saline treatments (50 or 120 Mm Nacl) had higher chloride, sodium and soluble solids contents, and hence had more flavor than controls. Although this could increase prices, it was not regarded as an adequate compensation for yield losses (Chartzoulakis et al., 1993). Salt injury

symptoms (e.g. chlorosis, burn leaf margins and necrosis) developed at EC more than 2.7 mmohs/cm and were more server at higher salinity (Chartzoulakis, 1991).

The objectives of this study were: (a) to investigate the effect of water salinity applied at different stages of growth on yield and quality of cucumber, and (b) to determine the optimum irrigation treatment with well and desalinized water for the best growth and yield characteristics.

Materrials and Methods

The study was conducted during the spring and early summer season of 2004 at the Agricultural Research and Experiment Station in Dirab near Riyadh. Seeds of three greenhouse cucumber cultivars; Alasil, Alia and Copra were sown on 20/1/2004 in Jiffy 7 pots in the fiberglass greenhouse; and transplanted into soil on 10/2/2004. Two salinity levels in the irrigation water (I: well water with EC 2.61 mmhos/cm, II: desalinized water with EC 0.39 mmhos/cm) were utilized (Table1).

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

Characters	Well water	Desalinized water
EC mmhos/cm	2.61	0.39
pH	7.1	6.47
Ca^{++} $meq1^{-1}$	11.0	0.73
Mg^{++} $meq1^{-1}$	10.5	0.16
Na^{++} $meq1^{-1}$	14.65	3.5
K^{++} $meq1^{-1}$	0.56	0.1
HCO_3^{---} $meq1^{-1}$	4.7	0.325
Cl^{-} $meq1^{-1}$	12.9	1.85
$No3^{-}$ ppm	5.2	26.9
SO_4^{-} $meq1^{-1}$	14.61	0.9
SAR	4.66	5.11

Five irrigation treatments (IT) were applied at various stages of growth and for different time durations; (IT1) irrigation with desalinized water for the whole experimental period (105 days from transplanting which) represented the control treatment, (IT2) irrigation with desalinized water until the beginning of flowering stage (30 days) then irrigation with local well water, (IT3) irrigation with desalinized water until the beginning of fruiting stage (35 days) then irrigation with local well water. (IT4) irrigation with well water for 35 days then irrigation with desalinized water until end of experiment, (IT5) irrigation with local well water for the whole experimental period. Irrigation treatments started 7 days after transplanting, using drip irrigation system with the two different sources of water. The soil texture was 84% sand, 8% silt and 8% clay with pH 7.65 and EC 5.35 mmhos/cm. Temperature and R.H. were averaged about 20

& 24 C° and 75 & 80% during vegetative growth and fruiting stages, respectively. Fertilization and other cultural practices, such as pest control, cultivation and pruning were applied as commonly recommended in commercial production of greenhouse cucumber (Yamaguchi, 1983).

The experimental units consisted of 15 treatments (five irrigation treatments and three cultivars). The experimental layout was split-plot in randomized complete blocks design with four replication. Irrigation treatments were randomly allocated to the main plots, whereas, cultivars were arranged in the sup-plots. Plot area was 5 m^2 included 15 plants. Planting distance was 50 cm and 70 cm between plants and rows, respectively.

Two plants were randomly selected from each sub-plot, six weeks after starting the irrigation treatments (at flowering stage), plant height, leaf number, leaf area, leaf fresh weight, leaf dry weight percentage were recorded. A random representative sample consisting of 10 fruits was taken from each experimental unit at the tenth harvest. The following fruit characteristics were determined: average fruits length, average fruit diameter, average fruit weight, fruit dry weight (DW) percentage and fruit firmness. Harvesting started on 20 March, 2004 and continued two times a week until 29 May, 2004 (20 harvests). Average early yield, represented as the number and weight of fruits per plant and per square meter, was counted from the first seven harvests. Whereas, total yield included the entire harvest period.

Data were statistically analyzed using SAS (Ray and Sall, 1982) software, and treatment means were compared by using L.S.D. test at 0.05 level according to Steel and Torrie (1980).

Results and discussion

Effect of irrigation treatments:

Irrigation treatments did not have significant effect on plant height, leaf number and leaf dry weight percentage (Fig.1A,B and D). However, irrigation with IT5 caused a significant reduction in leaf area and leaf fresh weight (28.1% and 12.2% respectively, compared to control IT1 (Fig.1C and E). These results clearly indicated that the decrease in leaf dry weight by salinity is not caused by a reduction in leaf number, but by a reduction in leaf area. This observation is in agreement with data reported by Van Iperen (1996) on tomato. Ho and Adams (1994) found a 46% reduction in dry weight of cucumber plants when the salinity level increased from 3 to 8 mmhos/cm. No significant differences were found between IT2, IT3 and the control irrigation treatment, since saline water was applied at flowering and fruiting stages in IT2 and IT3 treatments, respectively. In addition, IT4 did not reflect any negative effect on leaf area and leaf fresh weight.

Irrigation treatments IT2 and IT5 adversely affected on fruit length, fruit diameter and fruit firmness characteristics (Fig.2A,B and E). However, IT2 and IT3 did

not reflect any negative effects on the three fruit characteristics as compared with the control (IT1). Irrigation treatment IT5 significantly increased fruit DW percentage (Fig.2.D) while other treatments reflected negative effects on this trait. The reason for this result could be attributed to the increase in the soluble solids contents (Abd Allah et al. 1992). These data are in accordance with suggestion of Adams et al. (1994 &1995), who reported that dry matter (DM) accumulation of plants decreased with increased salinity, but DM of fruits increased. Increasing salinity reduces DM production and increased the proportion of total DW in the fruits at the expense of the upper shoot. In the case of average fruit weight (Fig.2.C), No significant differences were observed among all irrigation treatments, except for IT5, which reflected the highest value. This finding could be attributed to the higher reduction in total yield than reduction in number of fruits when IT5 was applied.

With respect to early yield per plant (Fig.3.A), irrigation treatment IT5 caused a significant reduction by 46.8%, while the reduction caused by IT2 was not significant (13.6%). No significant differences were found between IT3 and IT4 They resulted in intermediate negative effects (reduced the early yield by 23.7% and 25.6% respectively). Number of fruits per plant for early yield was not affected by the irrigation treatments (Fig.3.B). Only the longest duration of salinity treatments (IT5) caused a significant reduction in this trait. Reduction in early yield accounted by salinity was partial similar and in agreement with those reported by Jones (1984) and Al Harbi (2001).

Irrigation treatments IT5 caused significant reduction in total yield per plant by 28.3%, (Fig.3.C), while the reduction caused by IT2 and IT3 was 15.5% and 14.6%, respectively. Irrigation treatment IT 4 only reduced the total yield by 7.2%, as compared to control. This result indicated that the cucumber plants were more sensitive to salinity in irrigation water at fruiting stage than at vegetative growth stage. George and McCollum (1980) reported that cucumber plants require a continuous supply of moisture during the growing season, the most critical need occurs at the time of fruiting. Moisture stress then can seriously reduce the yield of marketable fruits. Concerning total number of fruits per plant, the trend was similar to this obtained by total yield as previousouly described. The reduction in yield even at relatively short duration of irrigation with saline water (i.e. IT4) supports the finding of Cuartero and Fernandez, 1999) that even under normal growing conditions the, EC of the root solution is close to the threshold for yield reduction. When irrigation with fresh water and fertilization were done normally, the saturated soil extract varied between 1.6 and 3.1 mmohs/cm (Maas 1984). Many other investigators reported significant negative effects in cucumber yield as a result of irrigation with saline water (Jones, 1984; Martinze and Gerda, 1987; Chartzulakis et al., 1991&1994 and Al-Harbi et al., 1995&2001).

Response of cultivars to irrigation treatments:

Significant differences among cucumber cultivars were found in all vegetative growth characteristics; except for leaf dry weigh percentage (Fig.4). The cultivar Copra gave significantly the highest values in all parameters. However, no significant differences were found between Alia and Alasil, except for plant height which was higher in Alia.

No significant differences were observed among the three cultivars in fruit length, fruit dry weight percentage and average fruit weight (Fig.5). However, in the case of fruits firmness, the cultivar Copra reflected the highest value followed by Alasil and Alia, respectively. On the other hand, Alasil had the highest fruit diameter.

The cultivar Copra had the highest and significant values for early and total yield per plant, followed by Alia and Alasil, respectively ((Fig.6) . With respect to number of fruits per plant for early yield, Alia gave the highest value followed by Alasil and copra respectively. No significant differences among cultivars were observed in total number of fruits per plant. Response of cucumber cultivars to irrigation treatments reported in this study are in partial accordance with those of reported by Jones et al. (1989) who studied the effect of 2 levels of salinity (1.6 and 4.0 mmhos/cm) on yield and fruit quality of cucumber cultivars. They reported that salinity significantly decreased fruit yield in 5 of 6 cultivars, but had no effect on fruit quality.

Considering that all traits were less severely affected by IT4 and that total yield was only reduced by 7.2% , as compared to IT1, it can be concluded that the use of salinized irrigation water until fruit setting stage followed by desalinized water is recommended for greenhouse cucumber production to save the high cost of water desalinization.

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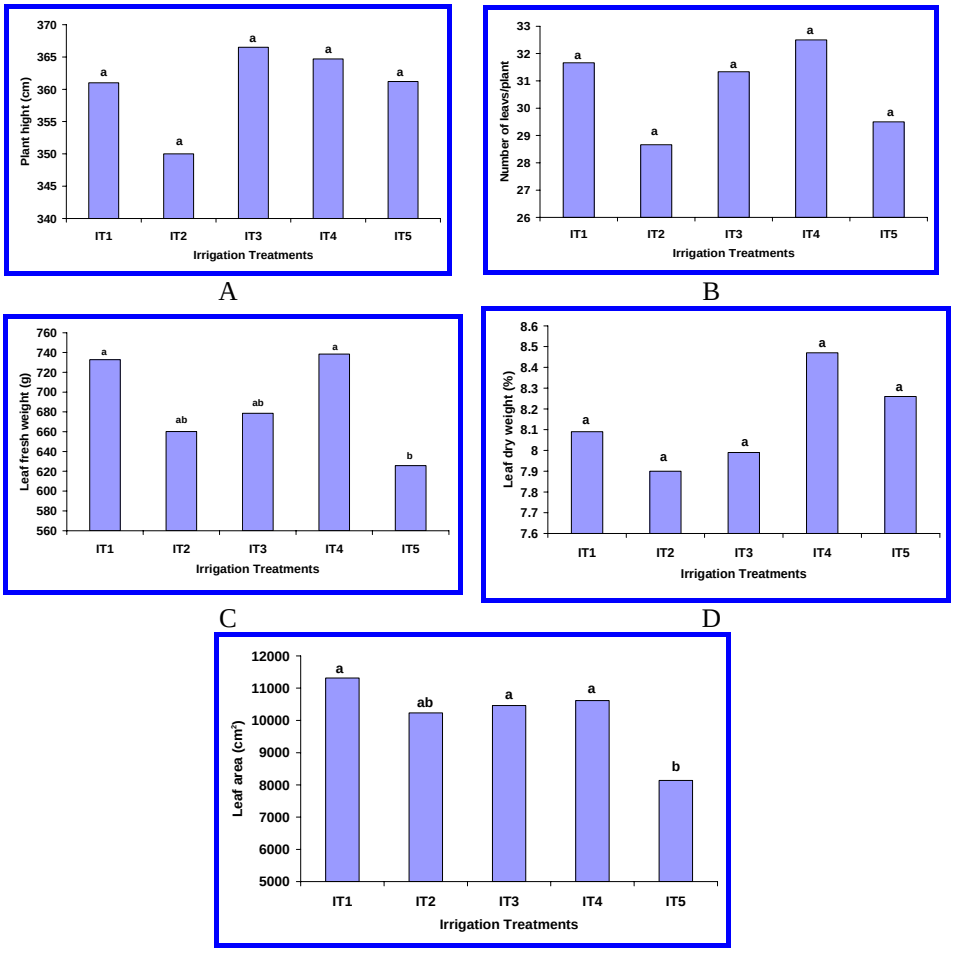

Fig. 1 Vegetative growth characteristics of cucumber plants as affected by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth): A. Plant height (cm) B. Number of leaves/plant
C. Leaf fresh weight (gm) D. Leaf dry weight (%)
E. Leaf area (cm^2)

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly different using the revised L.S.D test at 0.05 level.

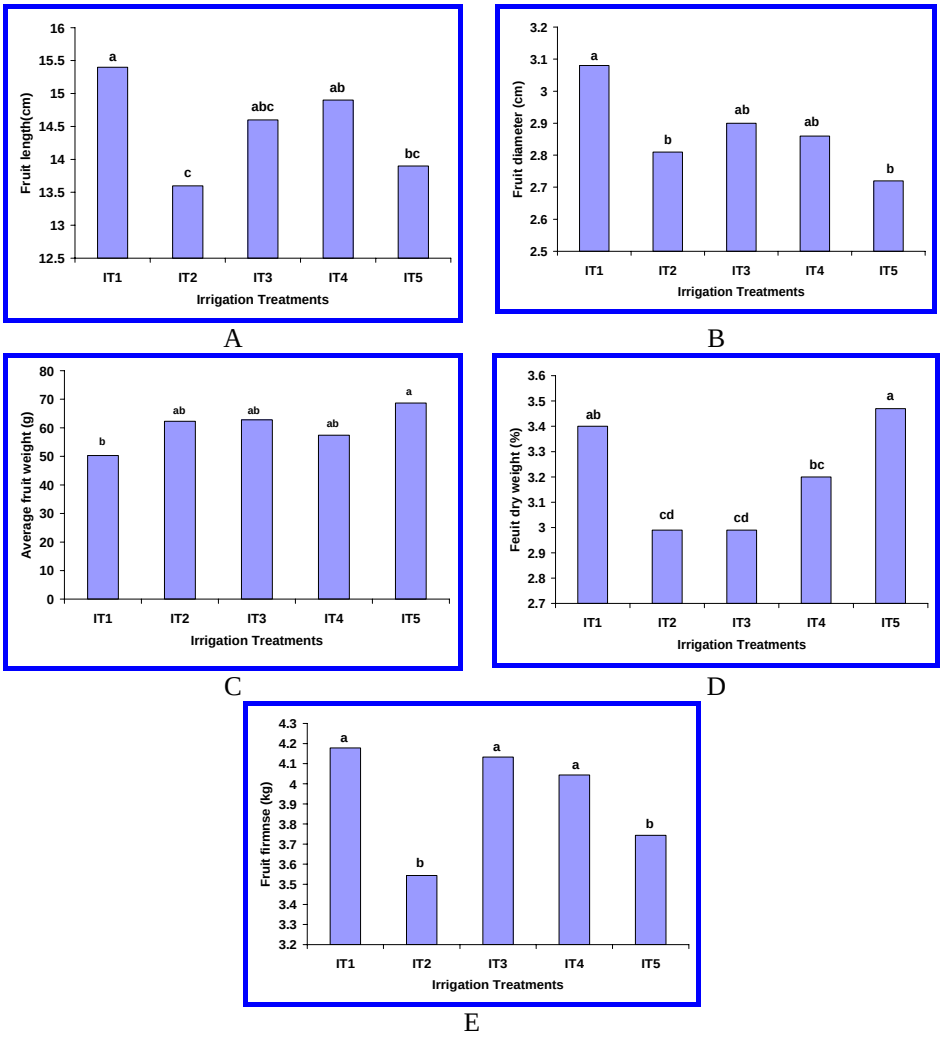

Fig. 2. Fruit characteristics of cucumber plants as affected by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth):
A. Fruit length (cm) B. Fruit diameter (cm)
C. Average fruit weight (gm) D. Fruit dry weight (%) E. Fruit firmness

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly different using the revised L.S.D test at 0.05 level.

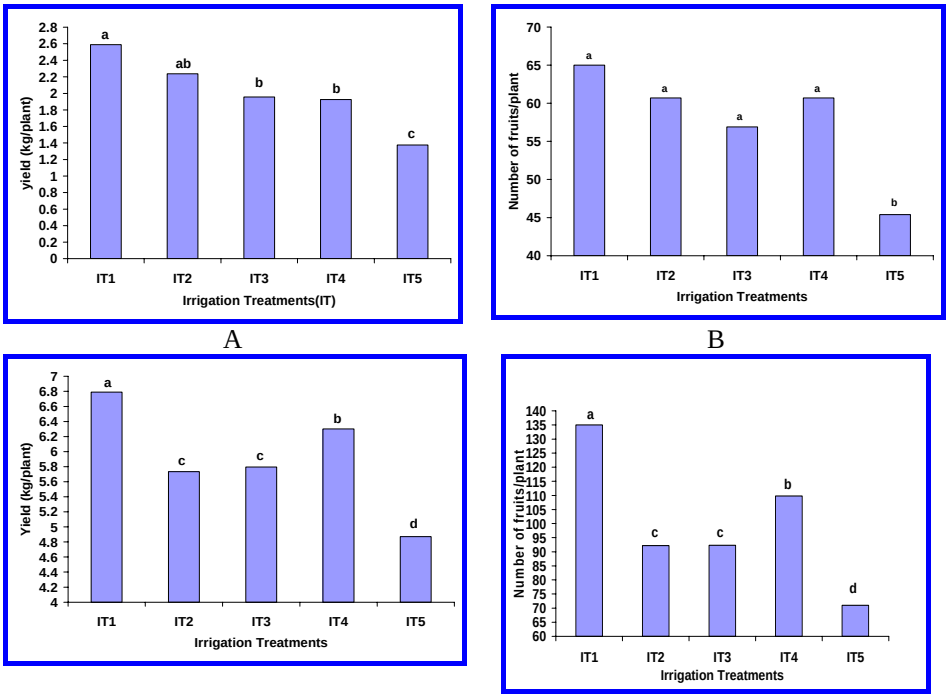

Fig. 3. Yield and yield components of cucumber plants as affected by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth):

A. Early yield (kg/plant) B. Number of early fruits/plant)

C. Total yield (kg/plant) D. Number of total fruits/plant)

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly different using the revised L.S.D test at 0.05 level.

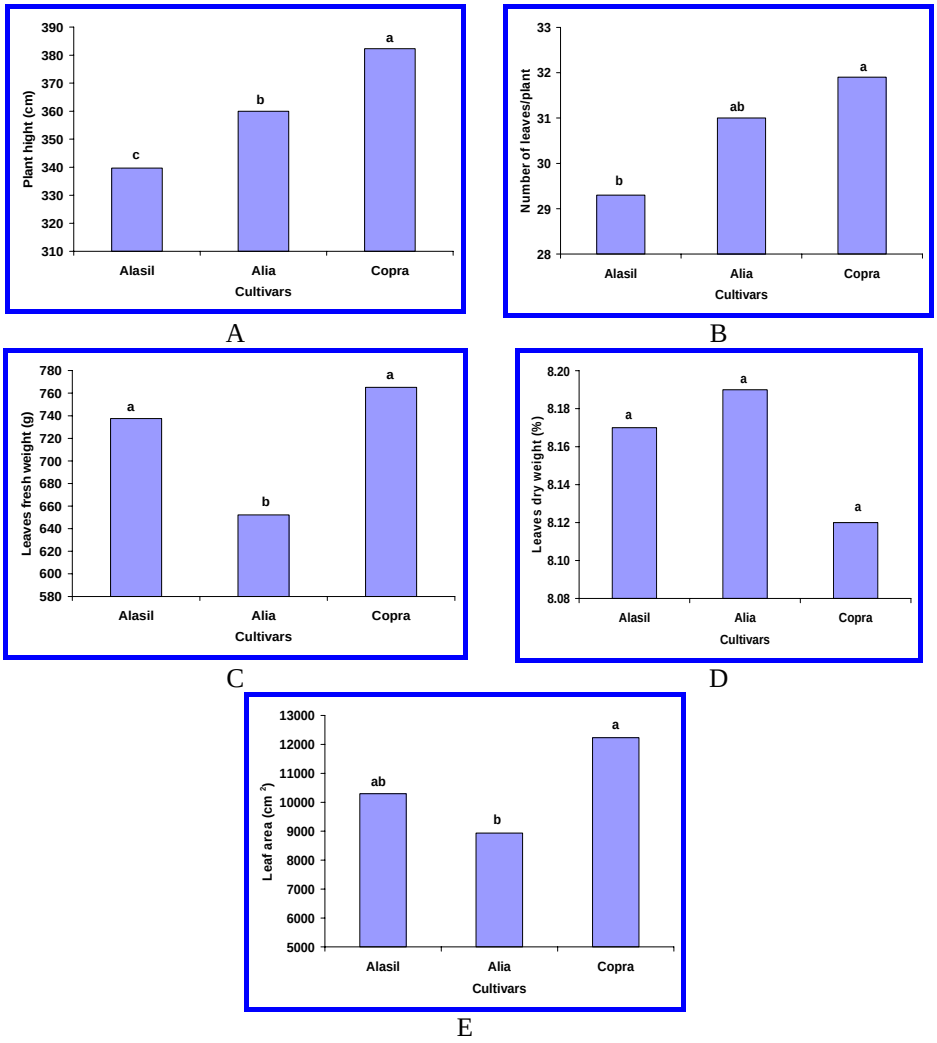

Fig. 4. Vegetative growth characteristics of three cucumber cultivars as influenced by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth): A. Plant height (cm) B. Number of leaves/plant C. Leaf fresh weight (gm) D. Leaf dry weight (%) E. Leaf area (cm^2)

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly differ using the revised L.S.D test at 0.05 level.

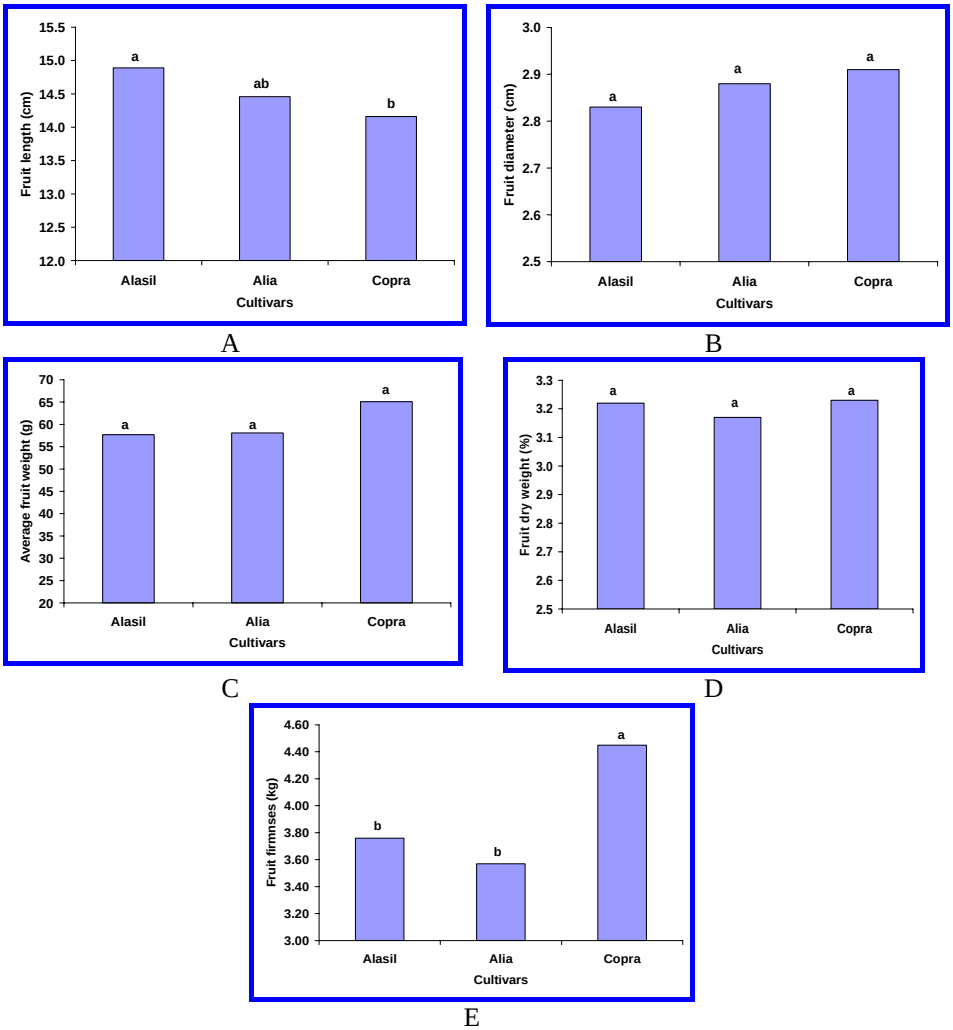

Fig. 5. Fruit characteristics of three cucumber cultivars as influenced by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth): A. Fruit length (cm) B. Fruit diameter (cm)
C. Average fruit weight (gm) D. Fruit dry weight (%)
E. Fruit firmness

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly differ using the revised L.S.D test at 0.05 level.

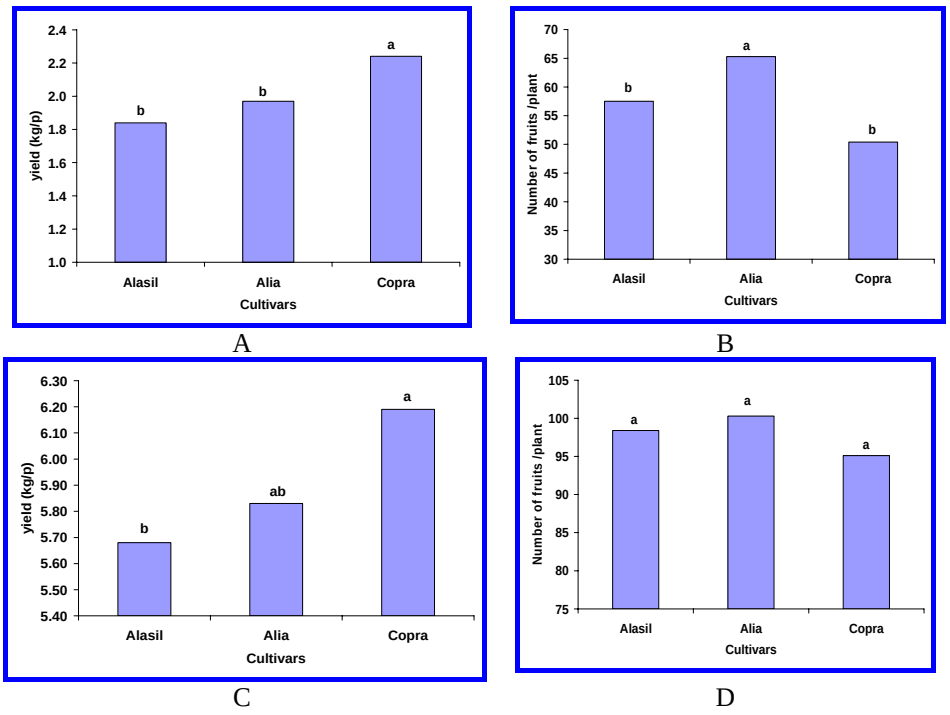

Fig. 6. Yield and yield components of three cucumber cultivars as influenced by five irrigation treatments (two levels of salinity in the irrigation water applied at various stages of growth):

A. Early yield (kg/plant) B. Number of early fruits/plant)

C. Total yield (kg/plant) D. Number of total fruits/plant)

* Bars in each graph sharing the same letter(s), within a particular group of means in each characters, are not significantly differ using the revised L.S.D test at 0.05 level.