

EFFECT OF IRRIGATION WATER SALINITY ON SWEET PEPPER YIELD AND ITS WATER PRODUCTIVITY UNDER DRIP IRRIGATION

**FAWZIA A. NAGM AL DEEN²; MOHAMED Y. EI ANSARY¹;
MONTASER A. AWAAD¹; WAEL M. SOLTAN²**

1. Faculty of Agriculture, Banha University, Mushtoher, Egypt.

2. Agricultural Engineering Research Institute (AENRI), Dokki, Giza, Egypt.

(Manuscript received 12 December 2018)

Abstract

Availability of fresh surface water for irrigation is declining in Egypt and saline ground water is increasingly used for irrigation. A field experiment was carried out on a sandy soil at Dokki protected cultivation experimental site, Agriculture Research Center (ARC), Ministry of Agriculture and Land Reclamation during summer and winter season of 2017-2018, to evaluate the effect of water quality and drip irrigation management on sweet pepper (*Capsicum annuum* L. cv. Top star) plants under surface drip irrigation. The experiment consists of three treatments of water salinity (EC) with and without adding the needed leaching requirements (LR). The water salinity treatments were the control (S_c) where $EC = 0.4\text{ds/m}$, ($S_{3\text{ds/m}}$) where $EC = 3\text{ds/m}$ and ($S_{5\text{ds/m}}$) where $EC = 5\text{ds/m}$, leaching requirement (LR) was applied after 2 months from transplanting. LR treatments were S_{cLR} , S_{3LR} and S_{5LR} . It was found that irrigation with different salinity levels and Leaching requirement both affected the growth characteristics, yield and irrigation water productivity of sweet pepper plant. It was concluded that more salt accumulation in the root zone could lead to higher potential yield losses of sensitive and moderately sensitive crops, such as sweet peppers. Also, it was found that the higher the salinity in the irrigation water the less the plant height, the roots fresh weight, and the number of fruits per plant. As well as the higher the salinity in the irrigation water the more concentration of Na, Cl, TSS and proline in fruits. It was observed that the highest peppers yield (2.89 Kg/m^2) and the best irrigation water productivity (1.04 Kg/m^3 water) were obtained from the fresh water treatment with LR management (S_{cLR}). While, irrigation by saline water with LR S_{3LR} and S_{5LR} treatments reduced peppers yield by 19% and 66% compared with S_c respectively.

Keywords: water quality, capsicum annum L, leaching requirement, salt tolerance, fruits quality.

INTRODUCTION

Egypt faces many challenges, including the low availability of fresh surface water for irrigation and the need to expand the area of agricultural land to achieve self-sufficiency of the country through the newly established projects on the land of Egypt, resulting in increased demand for the use of saline ground water.

Saline water is an important resource in arid areas and areas with poor quality groundwater resources. Use of poor quality water poses serious loss in yield and plant growth. Drip irrigation forms a wetting front that reduces the salinity around the root and

hence optimizing the conditions suitable for growth. Cost of sustaining crop production using saline water is variable according to resource availability, economy and social preferences (Gaurav,2016). For example, in Egypt, 3 to 4 thousand million m³ of saline drainage water are used for irrigation of about 405,000 ha of land. About 75 percent of the drainage water discharged into the sea has a salinity of less than 3,000 mg l⁻¹. (Hamdy, 2002).

Drip irrigation, with its characteristic of low rate and high frequent irrigation applications over a long period of time, can maintain high soil matric potential in the root zone thus compensate the decrease of osmotic potential introduced by the saline water irrigation, and the constant high total water potential can be maintained for the crop growth (Kang, et al, 2004).

Pepper is one of the most important, popular and favorite vegetable crops cultivated in Egypt for local consumption and exportation. It covers a production area of old lands 2395 feddans that yielded 14963 tons and production area in new lands (Ismailia, New Valley, North Sinai and Nubaria) 3574 feddans that yielded 26311tons, according to Ministry of Agriculture Statistics in 2016-2017. In Egypt, greenhouse pepper production is based on nine-month cycle. The transplants go into the production in plastic house in approximately first of August at age of six weeks; the first pick of fruits begins in about mid-December and continues until June (Bar-Tal et al., 2001). The most important problems facing sweet pepper production in Egypt is soil-borne pathogens, nematodes and soil salinity. The aim of this research was to evaluate the effect of using three water salinity levels under drip irrigation management on the growth and yield of sweet pepper (*Capsicum annum* L. cv. Top star) as well as on its water productivity. Also, the effect of applying the needed Leaching Requirements to all irrigation treatments was studied.

MATERIAL AND METHODS

Experimental site and conditions

A field experiment was conducted during summer and winter season of 2017-2018 at Dokki Protected Cultivation Experimental site, Agriculture Research Center (ARC), Ministry of Agriculture and Land Reclamation, Egypt (latitude 30° 02' 46.1"N, longitudes 31° 12' 16.6" E, and 27m altitude), to study the effect of using different water salinity levels on: the growth and yield of sweet pepper (*Capsicum annum*) cv, top star under drip irrigation system. As well as, evaluate the effect of using leaching requirement on decreasing the harmful effect of high salinity levels on pepper. The study was conducted in a shade greenhouse of 360 m² (9 m width, 40 m length and 3.2 m height). The experimental area has an arid climate with cool winters and hot dry summers.

Treatments and experimental design

In the year of 2017-2018 the experiment was designed using randomized completely block design with six replicates. The treatments were assigned to salinity levels **S_c** control water, **S₃** irrigation with 3 ds/m saline water , **S₅** irrigation with 5 ds/m saline

water and Leaching requirement, **S₁LR** adding 10% LR with control water, **S₃LR** adding 21.4% LR with $S_{3ds/m}$, and **S₅LR** adding 37.5% LR with $S_{5ds/m}$. Each plot consisted of 3 lateral lines (one without LR, and 2 with LR), each lateral contain 6 plants (in 6 pots). The different three salinity levels were prepared by adding Rashidy salt to tap water (containing about 99% NaCl, Na= 31.64% and Cl =67.45%.

Plastic pots of 120-liter volume used. Each pot filled up to about 2 centimeters from its upper edge, with 11Kg of washed sand. Each pot had holes in the bottom to drain the surplus of the irrigation water.

The experimental drip irrigation system (Fig.1) had

- 1) Three tanks (220 liters) installed to supply the three levels of water salinity. Each tank connected with its corresponding salinity level treatment all over the greenhouse through drip irrigation network. by means of one-inch PVC ball valve.
- 2) Drip irrigation network (as shown in fig.1.) consisted of a 0.45 hp (0.37 kW) water pump, a 120 mesh disc filter, 32 mm UPVC main and sub main lines, 25 mm UPVC manifold, 16 mm PE lateral lines (GR) with 4l/h emitters, and 3 ball valves.

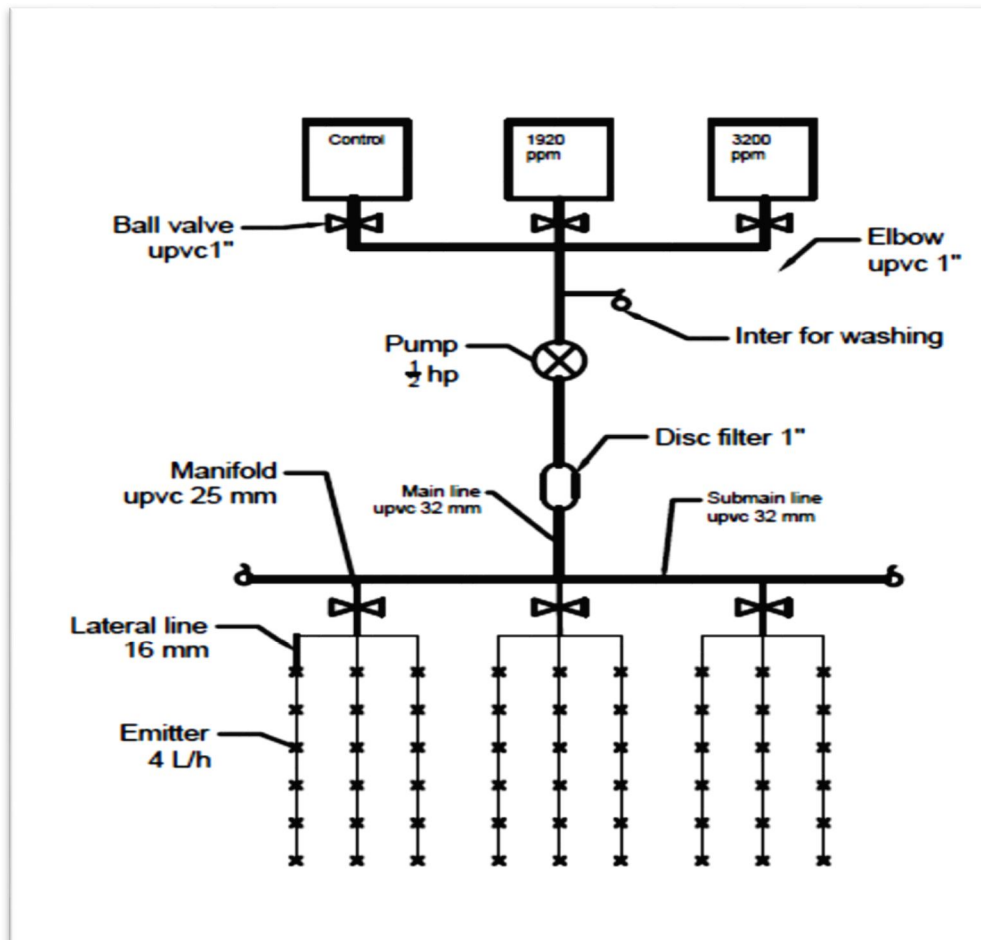


Fig. 1. Schematic diagram of the field experiment.

Seeds of sweet pepper (*Capsicum annuum* L. cv. Top star) were sown on 1st of August, 2017. Height of each plant was measured once a month. Pods were harvested when they reached horticultural green mature stage and fresh pod weights were measured. Plants were hand harvested at the end of the growing season and the fresh weights of fruits were recorded. Irrigation water productivity (IWP) was calculated.

Fertilizer requirements of peppers crop were applied properly according to recommendations of agronomy research institute, ARC, Ministry of agriculture and land reclamation, nutrient solution used in the experiment was described by El Behiary (1994) Table (1). The nutrient solution was completely renewed once a week by adding it in tanks after making the salts solution in the required concentration 3, 5 dS/m.

Table 1. Element concentrations in the nutrient solution.

Elements	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B	Mo
Concentration (ppm)	200	70	300	190	50	5.0	1.0	0.039	0.044	0.17	0.1

The daily amount of irrigation requirement for peppers crop were calculated according to the data provided by the Central Laboratory for Agriculture Climate (C.L.A.C), Ministry of agriculture and land reclamation for the study location (Giza Governorate) using Penman-Monteith equation (Allen *et al.* 1998). The five day prediction of water demand was created daily and allowed the further specific irrigation.

The average of predicted evapotranspiration, ETo, (obtained from the numerical models that calculated from the five day prediction of water demand) was used to estimate the daily water consumption.

The FAO crop coefficient (Kc) was adjusted according to local climatic conditions, including minimum relative humidity, wind speed and maximum plant height. The values in the period of the cropping season were as the following:

- Initial (30 days) = 0.3-0.5
- Development (40 days) = 0.7- 0.75
- Mid-season (110 days) = 1.0 -1.1
- Late-season (30 days) = 0.9 – 0.7

They were calculated in those periods in which plants were not under stress. The drip irrigation efficiency was assumed to be 0.89.

The calculated ETo values with the crop coefficient (Kc) that depend on plant growth stage were used to calculate the amount of water requirement for peppers m³/ plant/day with the following equation:

$$IW = \frac{ET_o * Kc * kr * A}{(1 - LR) * Ea * 1000}$$

Where:

IW = Irrigation water requirements under drip irrigation system, m³/plant/day.

ET_o = Reference evapotranspiration (mm/day).

Kc = crop coefficient.

Kr = Reduction factor (Keller and Karmeli, 1974).

A = the irrigated area (0.5*0.6 m² for one plant in this paper).

Ea. = Irrigation efficiency of drip irrigation system, %.

(FAO) recommends computing LR as (Ayers and Westcot, 1985):

$$LR = \frac{EC_{iw}}{(5 * EC_e - EC_{iw})}$$

Where EC is the electrical conductivity, iw denotes irrigation water, EC_e is the EC of the soil saturated paste extract corresponding to the soil salinity tolerated by the crop

Soil samples were obtained from each plot by auger after one month from transplanting to calculate leaching requirement and repeated at the end of the experiment to plot the salinity distribution patterns throughout the root zone depth below the emitters. The horizontal sampling distances from emitters were 0-5, 5-10, 10-15, 15-20 and 20-25, while the sampling depths were 0-5, 5-10, 10-15, 15-20 and 20-25 cm. Soil salinity was Determined in the laboratory by using a conductivity meter (Marcus and Richard, 2012).

Plant height from soil surface (cotyledons level) to the terminal bud was measured after 30, 60, 90,120,180 and 210 days from transplanting date. , early yield and the early fruit number were counted from the beginning of the harvest the end of December until the end of January. The cumulative yield and fruit number calculated after each harvest and the total fruit weight per plant was determined. The proline (PRO) content estimated by the method of Bates *et al.* (1973).

Irrigation Water productivity (IWP) is defined as the pepper fresh fruit yield obtained per unit of the total seasonal irrigation water applied. Irrigation water productivity (IWP) was used to evaluate the effects of irrigation regimes and salinity treatments on the pepper productivity. It was calculated by using the following equation: (Nagaz, *et al.* 2012).

$$IWP = \frac{Y}{IW}$$

Where, Y is the absolute actual yield (kg/m²) and IW is the irrigation water applied in different irrigation regimes (m³/ m²).

The data obtained from the experiment were analyzed using a single factor analysis of variance (ANOVA) and the means of different treatments were compared using least significant different test (LSD) by SPSS. Significant differences were determined at $\alpha = 0.05$ level of significance.

RESULTS AND DISCUSSION

Effect of irrigation water salinity levels on soil salt distribution patterns:

Figs. (2 , 3 and 4), show soil salt distribution patterns under different drip irrigation water salinity levels.

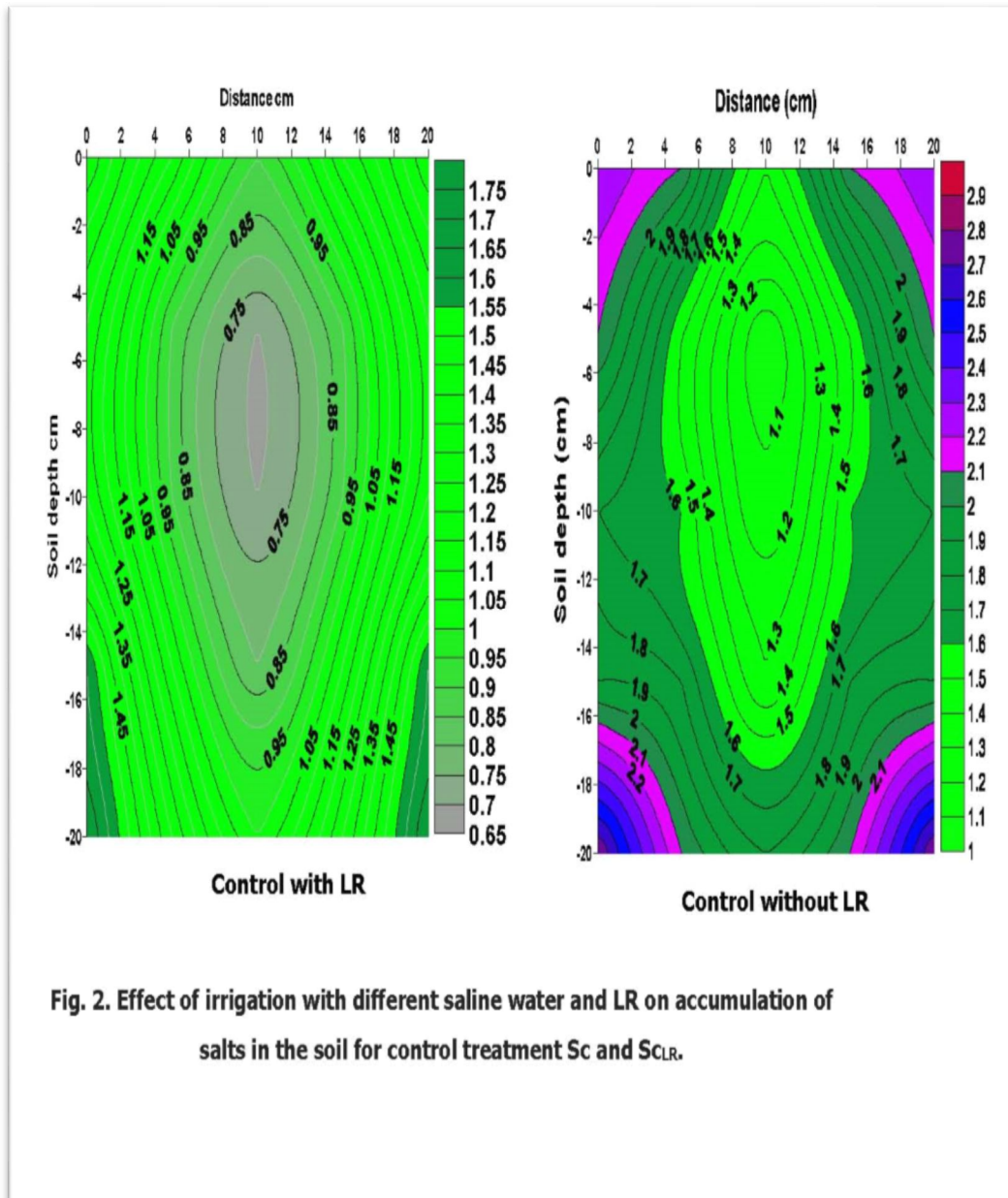
At the beginning of the season, EC_e was 0.67 ds/m for all treatments. While, at the end of the experiment, salinity in the soil profiles of irrigation treatment S_c (control) ranged between 1.1 to 2.8 ds/m. At the end of the experiment, Fig (2), indicated that soil salinity became 1.4 directly under the emitter and increased with moving away from the emitter, while it reached the maximum value at the bottom of the wetted cone ($EC_e = 2.8$ ds/m) ,as well as it reached 2.3 ds/m at the upper edge of the wetted cone .

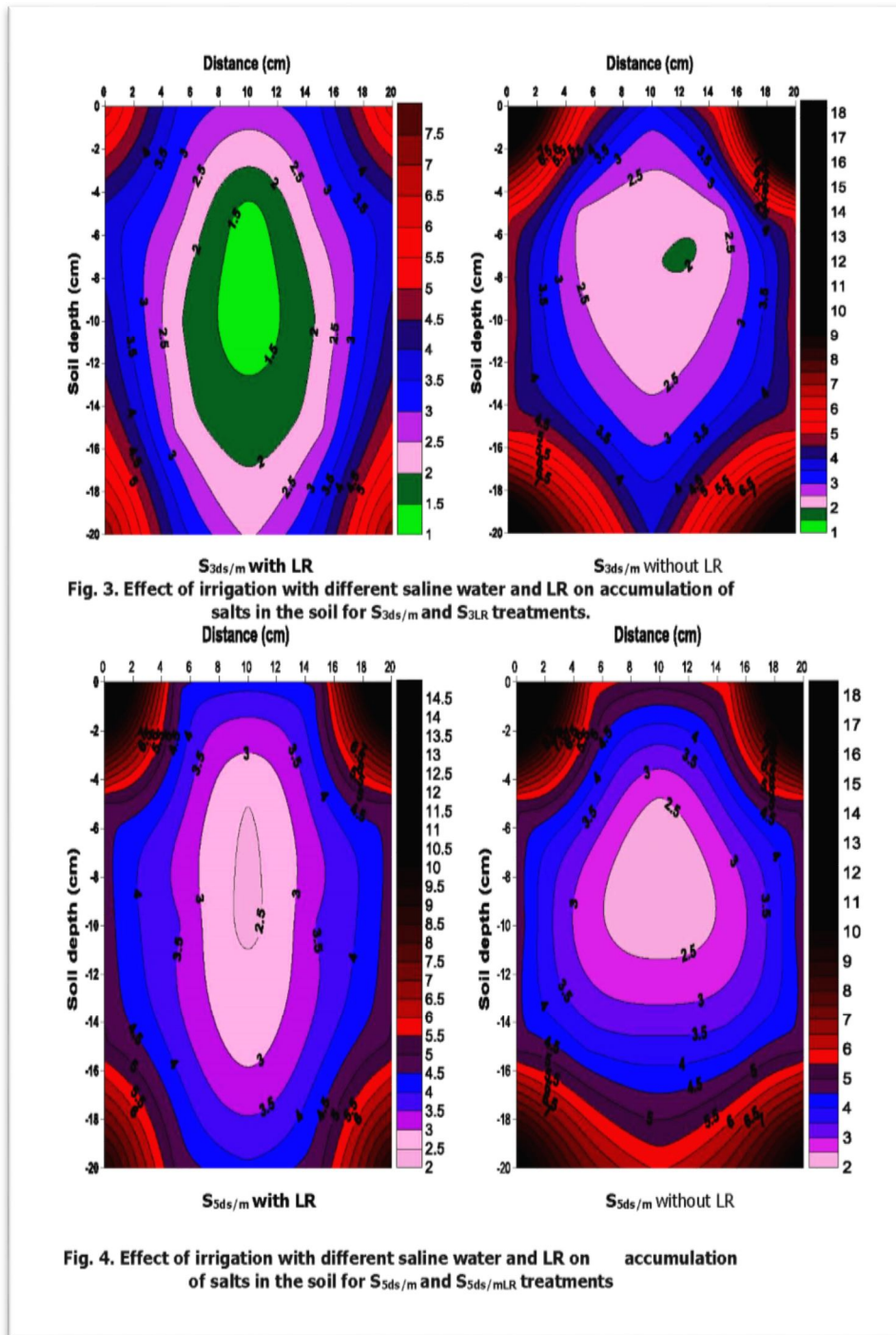
Salinity distribution in the soil profiles under other tested irrigation salinity treatments $S_{3ds/m}$ and $S_{5ds/m}$ ranged between 2.3 to 10.7 ds/m, and 2.6 to 12.7 ds/m respectively. Both distribution patterns indicated similar salt accumulation trend as that observed and mentioned above for the control treatment (S_c) except the higher salt accumulation values in those two treatments $S_{3ds/m}$ and $S_{5ds/m}$.

Due to applying the saline water at the soil surface, EC_e was high in outer places of the top soil layer of all treatments and generally decreased with depth, and then became highest in the bottom of the wetted zone.

Adding 10%, 21.4% and 37.5% as leaching requirements for S_{cLR} , $S_{3ds/mLr}$ and $S_{5ds/mLr}$ treatments improved salt movements far away from the center of the wetted soil under the emitters (effective root zone). Therefore, adding leaching requirements reduced the concentration of salt in root zone areas under emitters and redistributed its accumulation to be higher salt in deeper and outer layers of the wetted cone compared with the treatments without leaching requirements.

It could be concluded that using relatively high salt irrigation water should be applied in good drained soils with adding proper leaching under activated irrigation and drainage management.





Effect of irrigation with different salinity levels and LR on pepper vegetative growth:

Plant height

Fig. (5) Indicated that increasing salinity in irrigation water caused significant reduction in plants height. The results showed that plants in the control

treatments which irrigated by 0.4 ds/m were taller than those irrigated by saline water of 3 ds/m and 5 ds/m. The decrease ratio in the final plant height due to irrigation with saline water of 3 ds/m and 5 ds/m were 11.67% and 28.7% respectively .at the end of the experiment. So, it could be conclude that the higher the salinity of irrigation water the lower the height of pepper plants.

Concerning to the interactions between irrigation with different salinity levels and adding LR, it was found that adding LR=10% of irrigation water to the control treatment (S_{cLR}), adding LR=21.4% to $S_{3ds/mLr}$,and adding LR=37.5% to $S_{5ds/mLr}$ increased plant height by 14.7%, 9.3% ,and 14.3% respectively compared with plants height irrigated with the corresponding salinity levels without adding LR. Similar results obtained with Assouline *et al.*, 2006 ; Ben-Gal, *et al.*, 2008 and Baath, *et al.*, 2017.

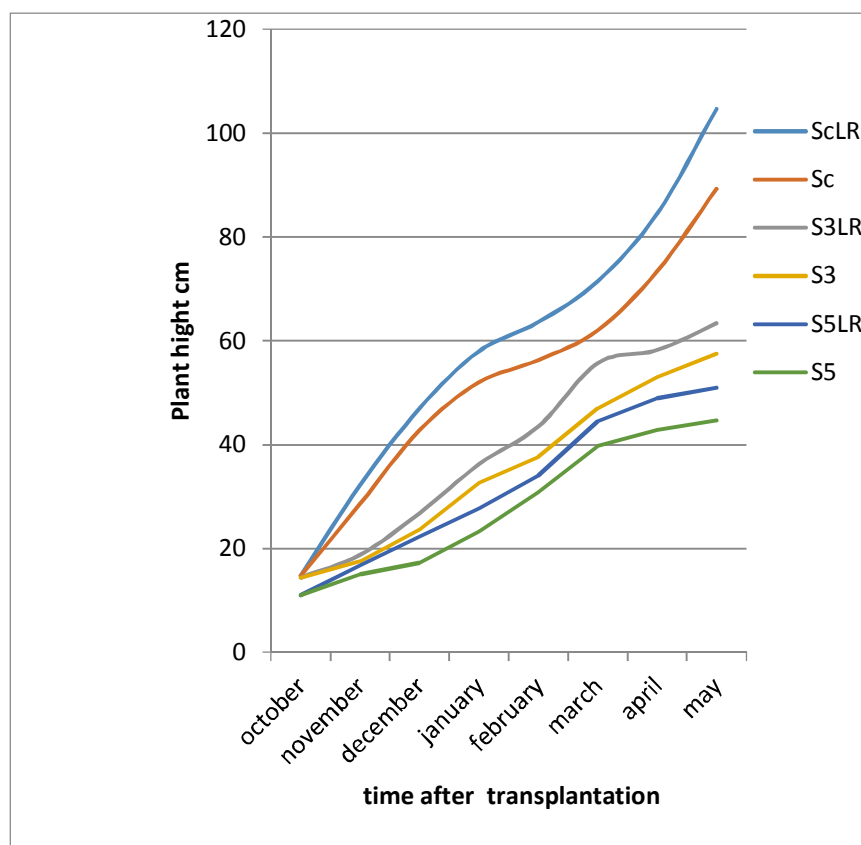


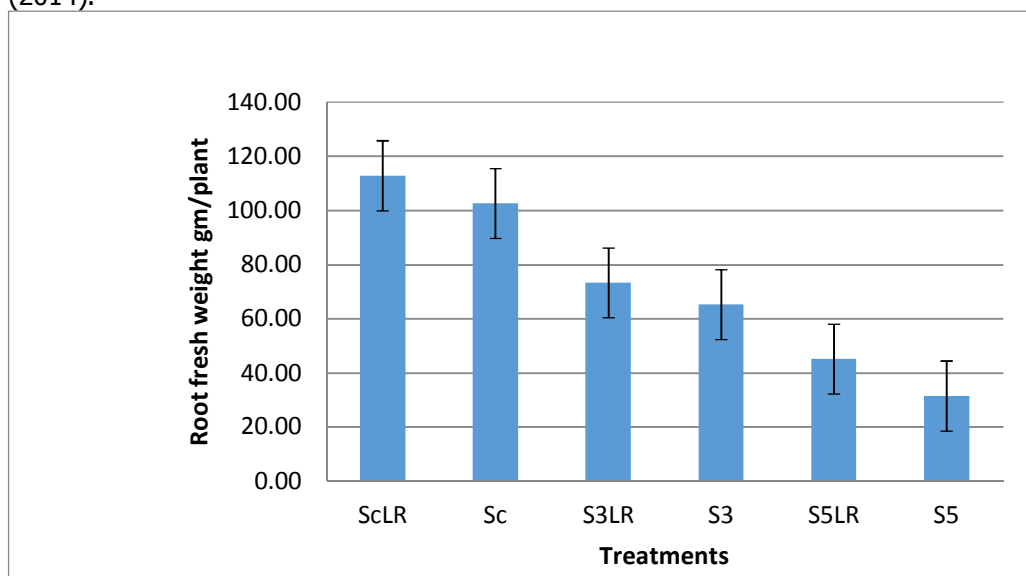
Fig. 5. Effect of irrigation with different salinity levels and LR on plant height.

It was demonstrated that there was a significant difference between relative plant heights in 0.4 (control), 3ds/m and 5 dS/m, indicating that peppers height is very affected by salinity.

Root fresh weight

Fig. (6) Indicated that there was a significant difference between treatments S_c , $S_{3ds/m}$ and $S_{5ds/m}$. The heaviest fresh weight of root was obtained in plants irrigated with control treatment water (S_c), and the lowest was in plants irrigated by 5 ds/m water salinity ($S_{5ds/m}$). The decrease ratios in roots fresh weight due to irrigation with saline water 3 and 5 ds/m was 36.5% and 69.4% respectively compared with S_c treatment.

Concerning to the effect of adding leaching requirement with irrigation water, it was found that adding LR 10%, 21.4% and 37.5% to S_c , $S_{3ds/m}$ and $S_{5ds/m}$ treatments increased pepper root fresh weight by 9%, 11%, and 30.4% respectively. Those finding are in agreement with this of Yildirim and Guvence (2006); Semiz *et al.*, (2014).



LSD ($p < 0.05$) = 3.76

Fig. (6) Effect of salinity levels and LR on pepper root fresh weight.

It could be concluded that salinity has a significant impact on the decrease of fresh weight of roots, but with adding leaching requirements, fresh weight of pepper roots was increased and this may lead to better yield and good quality of pepper.

Effect of irrigation with different salinity levels and LR on yield parameters:

Early and total fruit number

About the effects of irrigation with different saline water on both early and total fruit number. It was clear from **Fig. (7)** Illustrate that there was a significant difference in number of fruits per plant between S_c , S_3 , and S_5 treatments for both early and total numbers. The highest number was observed with control treatment (S_c) and the lowest was with S_5 treatment. It was also found that using saline

irrigation water 3 ds/m ($S_{3ds/m}$) and 5 ds/m ($S_{5ds/m}$) caused reduction in early fruit number by 35.5% and 76.9% respectively compared with S_c treatment. .

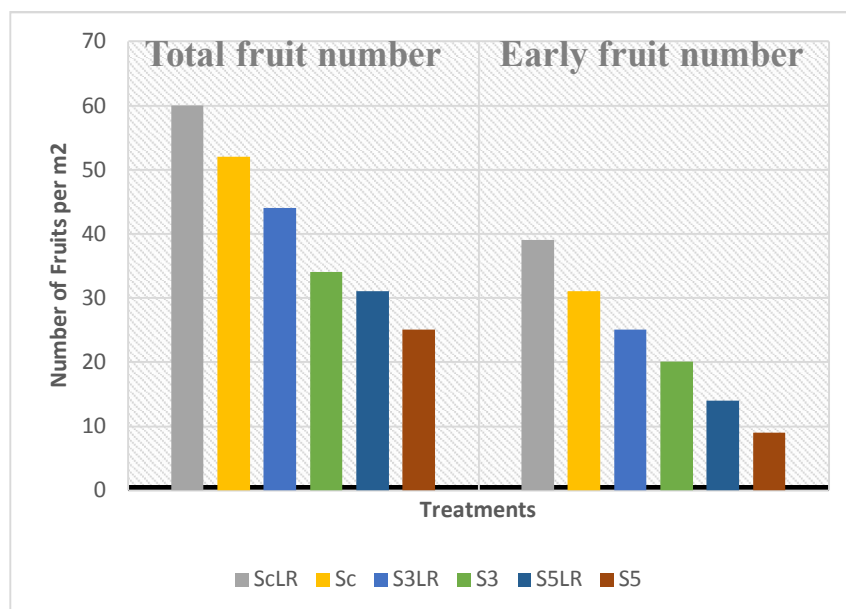


Fig. 7. Effect of irrigation with saline water and LR on fruit number per plant.

The results of total number of fruits from the beginning of February to the end of the experiment on the first of May were quite similar in its trend as that of early fruits number. The results showed that the control treatment (S_c) was the highest in the total number of fruits per m² (52). The lowest value was obtained by $S_{5ds/m}$ treatment.

Using irrigation with saline water 3ds/m, and 5ds/m caused reduction in number of fruit per m² about 34.6% and 51.9% respectively compared with control S_c . . These results were in agreement with Chartzoulakis and Klapaki 2000.

Concerning the effect of adding leaching requirement, it was found that adding 10% to the control treatment (S_c) (water salinity 0.4ds/m), it increased number of fruit per m² by 13.3% comparing with that in S_c without LR. In cases of adding LR with 3ds/m and 5ds/m irrigation water treatments, ($S_{3ds/m LR}$) and ($S_{5ds/m LR}$), the number of fruits per plant increased by 20.4% and 19.3% respectively. In other words, the use of Leaching requirement in $S_{3ds/m}$ and $S_{5ds/m}$ resulted in reducing the reduction in fruits number to be 15.3% and 44.2% only instead of 34.6% and 51,9% respectively as comparing with the control treatment (S_c). These results are in agreement with Ben-Gal, 2008.

Total fruit yield

Data in Fig. (8) Indicated that plants in treatment S_c (0.4ds/m) produced the highest total fruit yield compared with those plants in treatments of 3ds/m, and 5ds/m irrigation water salinity.

Fig. (8), also indicated that the decreasing rate of pepper productivity was about 46.3% in plants irrigated with 3ds/m water salinity, and 79.4% in plants irrigated with 5ds/m water salinity.

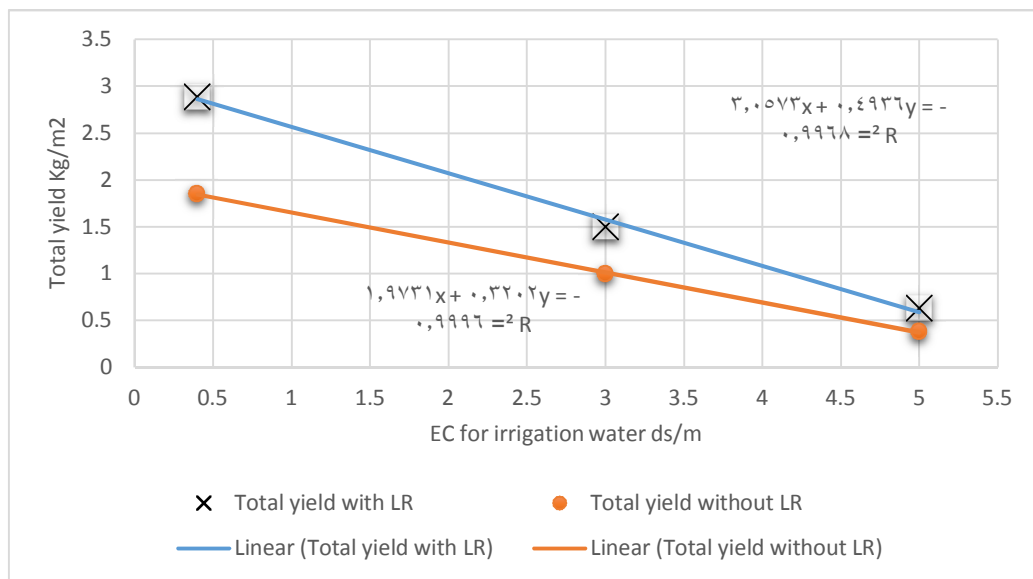


Fig. 8. Effect of irrigation with different salinity levels and LR on total yield.

Under this study conditions, it found that the relationship between pepper Yield (Kg/m²) and irrigation water salinity (ds/m) was **LINEAR**:

$$\text{Yield(kg/m}^2\text{)} = -0.3202\text{EC} + 1.9731$$

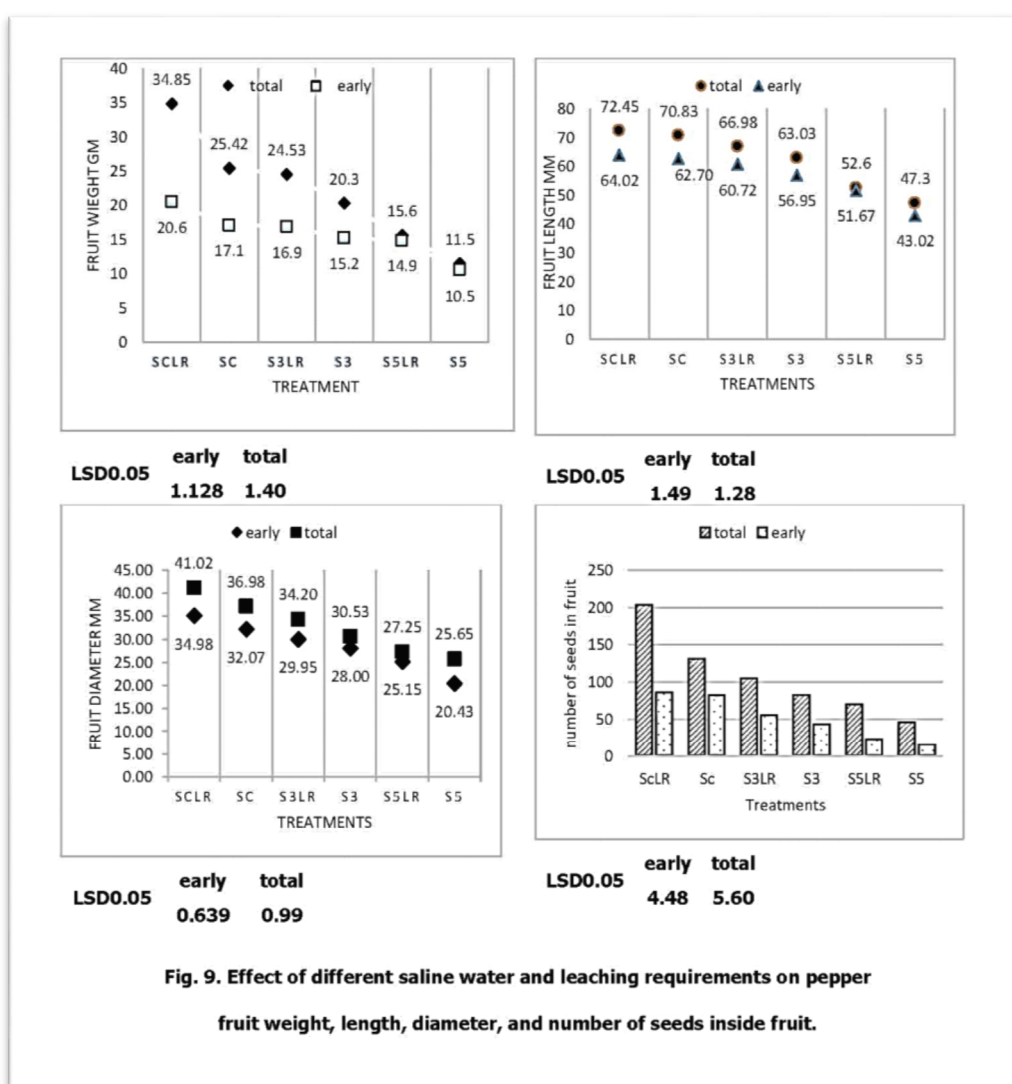
$$R^2 = 0.9996$$

Regarding to the effect of adding leaching requirement, the total fruit yield increased by 36.0% when 10% LR was applied in treatment S_{cLR} . while adding 21.4% and 37.5% LR to $S_{3ds/mLR}$ and $S_{5ds/mLR}$ treatments increased total fruit yield by 33.7%, and 39.5% respectively.

From the previous results, it could be concluded that, total fruit yield per plant decreased significantly with increasing salinity, due to reduction in both numbers and size of fruits. (That is in agreement with Malash, *et al.*, 2005 and 2007 ; Semiz, *et al.*, 2014).

Effect of irrigation with different salinity levels and LR on fruit properties:

To know the effect of irrigation with different saline water and leaching requirement on the physical properties of fruits, fruits weight, diameter, height and number of seeds inside the fruits were determined. first the effect of salinity levels on early and total fruit weight, fruit diameter and fruit height, it was found that there was a significant difference between treatments, the greatest value was with irrigation by the lowest water salinity (the control S_c), and the lowest values of fruit weight with irrigation by 5 ds/m saline water S_5 .



It was found that the effect of LR with S_c and $S_{3ds/m}$ on increasing total fruit weight was bigger than early fruit weight, but in $S_{5ds/m}$ the situation was different, increasing early fruit weight was more than total fruit weight.

High rates of leaching allow higher biomass production and essentially create threshold values below which E_{ciw} does not effectively reduce yields Ben-Gal, 2008. The reduction in fruit yield and shoot weight with salinity was in agreement with other salinity studies conducted on peppers (Yildirim and Guvence, 2006; Semiz et al., 2014; Baat et al., 2017).

From the previous data and graphs it could be concluded that using saline irrigation water reduced fruit length, diameter, and weight of sweet pepper and the more salinity the less weight and dimensions of sweet pepper. It could be stated also that adding LR was a very important process and it improved fruit physical properties especially in the early stage of plant life.

Use saline irrigation water reduce also number of seeds in sweet pepper fruits, as in fig. (9). The data showed that the more salinity the less number of seeds. Referring to the effect of adding LR with irrigation water on early and total number of seeds in sweet pepper fruits, it was found that adding LR with irrigation water had a significant effect on increasing number of seeds in fruits for early and total pepper yield. Number of seeds inside the fruit of pepper is an important factor in the development of new varieties, and also in seed sowing process.

Chemical analysis of fruits:

Table (3) displays the effect of irrigation with different salinity levels and LR on Na, CL, Ca, PH, TSS, and proline of pepper fruits. It was clear that The Na, and CL content in fruits was affected by salinity level. Increasing salinity level in irrigation water led to an increase in the Na and CL content of the fruits. This results in agreement with Navarro *et al.*, 2010.

Data revealed that higher salinity levels of irrigation water increased the TSS content of sweet pepper fruit. The increasing in TSS with high EC of irrigation water may be a result of reduced leaf area of pepper and number of fruit per plant resulting in less photosynthetic capacity, which will be aggravated by lower sugar transport of stressed plants. These results are correlated with Navarro, *et al.*, 2010.

The results showed that the pH number of peppers juice slightly increased because of increasing the salinity of irrigation water, and lower pH values were observed for control plants, this could be a consequence of the increase in organic acid concentrations, probably due to a higher ratio of inorganic cation/anion uptake, and this increases the total acidity and thus reduces the pH, this results are in agreement with NAVARRO, *et al.* 2010.

About the effect of irrigation with different salinity levels on the accumulation of proline in fruits, it was found that it was significantly higher in S_3 and

S₅ than control water S_c. concerning the effect of adding LR with irrigation water; it was clear from Table (3) that it decrease the concentration of proline in fruits.

Table 3. Effect of salinity levels and LR on Chemical properties of pepper fruits.

Chemical properties of pepper fruits							
Treatment	Anthocyanin g/100g	Proline mg/g	TSS	pH	Ca %	CL mg/100g	Na %
S _c LR	0.0071	0.193	9.9	5.35	0.223	1.904	0.55
S _c	.0717	0.254	9.7	5.425	0.232	2.306	0.62
S ₃ LR	0.1016	0.293	8.725	5.725	0.222	2.622	0.52
S ₃	0.1076	0.375	7.425	5.750	0.224	5.456	0.61
S ₅ LR	0.1025	0.386	7.9	5.825	0.222	3.571	0.53
S ₅	0.10940	0.443	7.1	5.850	0.222	3.999	0.58

From the table we find that high salinity increases the concentration of proline in fruits as a result of salt stress. The accumulation of free proline appears to be a large-scale response to the high Osmotic pressure in the plant. Many plant species respond rapidly to stressors by increasing the concentration of compatible solutes involved in osmoregulation and in protection of proteins and membranes in conditions of high salinity of irrigation water potential. This is in agreement with Gazik, 1996.

Effect of irrigation with different salinity levels and LR on Irrigation water productivity:

Fig. (10) Shows the effect of irrigation with different salinity levels and LR on Irrigation water productivity (IWP) of sweet pepper. Data revealed that the IWP values were decreased by increasing salinity.

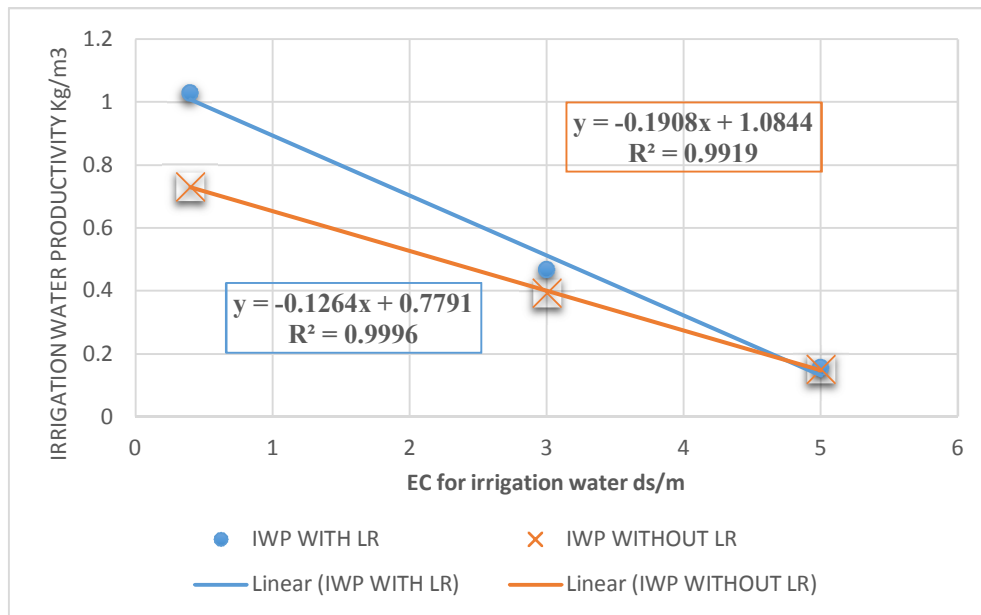


Fig. 10. Seasonal curve of Irrigation Water Productivity IWP for the different treatments, based on cumulative total yield and seasonal amount of applied irrigation water.

There are significant differences in the irrigation water productivity (IWP) due to the three salinity level treatments and adding leaching requirement. The greatest productivity was achieved in (S_c) control water 0.4 ds/m, while the least productivity was exhibited in $S_{5ds/m}$, which had the same amount of water added to control and the highest level of salinity 5ds/m. Therefore, that productivity affected by salinity levels.

Under this study conditions, it found that the relationship between pepper IWP and irrigation water salinity was linear:

$$\mathbf{IWP = -0.1264 EC + 0.7791}$$

$$\mathbf{R^2 = 0.9996}$$

Concerning the effect of adding LR with different saline irrigation water, data in **Fig. (10)** showed that the greatest value IWP was **1.03** kg/m³ under irrigation with water salinity 0.4 ds/m and 10% LR as in treatment (S_{cLR}). Despite the increase in the amount of water added to the plant due to the addition of LR with high rate (as occurred with the second treatment, 21.4%LR), but the increase in productivity compensated the increasing in water. IWP was **0.466** Kg/m³ for $S_{3ds/mL R}$, and **0.156** Kg/m³ for $S_{5ds/mL R}$.

It found that the relationship between IWP of pepper and irrigation water salinity with adding LR was Linear:

$$\text{IWP} = -0.1908 \text{ EC} + 1.0844$$

$$R^2 = 0.9919$$

Adding LR with saline irrigation water 3 ds/m (S_{3LR}) increased IWP by 17% compared with $S_{3ds/m}$ without LR. While, with $S_{5ds/mLR}$ adding LR=37.5% increased the amount of water from **2.53** m³/m² to **4.052** m³/m², and correspondingly increased IWP by only 6.25% compared with $S_{5ds/m}$ without LR. These findings are in agreement with those of Assouline, *et al.*, 2006 and Ben-Gal, *et al.*, 2008.

In general, the reduction in pepper Irrigation water Productivity with salinity was in agreement with other salinity studies conducted on peppers Rameshwaran, 2016.

CONCLUSION

In this study, the effects of different salinity irrigation water using a drip irrigation system on sweet pepper (*Capsicum annum* L.) investigated showed that increased levels of salinity induced a high level of salt accumulation within the pepper plants' root-zone, while increased saline irrigation increased the size of the salt affected layers within the root-zone. Adding leaching requirements reduced the concentration of salt in root zone especially in the depths that directly under emitters. The assessment of the effect of salinity on growth parameters of pepper allow us to conclude that all of the considered parameters were affected by salinity. Indeed, a significant effect of drip irrigation water salinity on relative plant heights, root fresh weight, and number of fruits per plant were found in all treatments (0.4 ds/m (control), 3ds/m and 5 dS/m). Total fruit yield decreased significantly with increasing salinity, due to reduction in both numbers and size of fruits. Using saline irrigation water reduced pepper physical properties. It could be stated also that adding leaching requirements (LR) was a very important process since it improved yield and fruit physical properties especially in the early stage of fruiting. Accordingly, the pepper Irrigation Water Productivity (IWP) negatively was affected by water salinity levels. However, adding leaching requirements with saline water under drip irrigation conditions increased both pepper yield and its water productivity (IWP).

RECOMMENDATIONS:

First, to pay attention to the application of Leaching Requirement according to soil type and salinity, salinity of irrigation water and the type of crop grown. Second, a good and efficient drainage system should be used with irrigation by saline water especially in heavy clay so that the addition of Leaching Requirement become effective.

REFERENCE

1. Allen, R.G., L.S. Pereira, D. Raes and M. Smith, 1998. Crop Evapotranspiration—Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drain Paper No. 56, Rome, Italy, 300pp.
2. Assouline, S., M. Moller, S. Cohen, M. Ben-Hur, A. Grava, K. Narkis and A. Silber. 2006. Soil plant system response to pulsed drip irrigation and salinity (bell pepper case study). *Soil Science Society of America* 70: 1556-1568.
3. Ayers R. and W. Westcot, 1985. Water quality for agriculture. In: *Irrigation and Drainage Paper No. 29*. FAO, Rome, Italy.
4. Baath G. S., M. K. Shuklaa, P. W. Boslanda, R. L. Steiner and S. J. Walker, 2017. Irrigation water salinity influences at various growth stages of *Capsicum annum*. *Agric. Water Manag.* (179) 246–253.
5. Bar-Tal A., B. Aloni, L. Karni, and R. Rosenberg, 2001. Nitrogen Nutrition of Greenhouse Pepper. II. Effects of nitrogen concentration and NO₃: NH₄ ratio on growth, transpiration, and nutrient uptake. *Hort Science*, 36 (7): 1252-1259.
6. Bates, L. S., R. P. Waldren and I. D. Teare, 1973. Rapid determination of free proline for water – stress studies. *Plant Soil* 39, 205–207.
7. Ben-Gal, A., E. Ityel, L. Dudley, S. Cohen, U. Yermiyahu, E. Presnov, L. Zigmond and U. Shani, 2008. Effect of irrigation water salinity on transpiration and on leaching requirements: a case study for bell peppers. *Agric. Water Manage.* 95, 587–597.
8. Chartzoulakis, K. and G. Klapaki, 2000. Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. *Scientia Horticulturae* (86) 247-260.
9. El-Behairy, U. A., 1994. The effect of levels of phosphorus and zinc in the nutrient solution on macro and micronutrients uptake and translocation in cucumber (*Cucumis sativus* L.) grown by the nutrient film technique. Ph.D thesis, London University p: 299.
10. Gaurav, J., 2016. A Review on Drip Irrigation using Saline Irrigation Water in Potato (*Solanum tuberosum* L.) <https://www.researchgate.net/publication/309619161>.
11. Gazik, A., 1996. Accumulation of Proline and Pattern of amino acids in sugar beet plants in response to osmotic, water and salt. *Environmental and Experimental Botany*, 36 (1) , 29-38.
12. Hamdy, A., 2002. Sustainable use and management of non-conventional water resources in the arid regions. *Acta Horticulturae* 573: 159-174.
13. Kang, Y., F. X. Wang, H. J. Liu and B. Z. Yuan, 2004. Potato evapotranspiration and yield under different drip irrigation regimes *Irrig Sci* 23: 133-143.

14. Keller, J. and D. Karmeli, 1974. Trickle irrigation design parameters. *Transactions of the American Society of Agri. Engi.*, 17(4): 678–684.
15. Malash, N., T. J. Flowers and R. Ragab, 2005. Effect of irrigation systems and water management practices using saline and non-saline water on tomato production. *Agric. water manage.* (78), 25-38.
16. Malash, N., T. J. Flowers and R. Ragab, 2007. Effect of irrigation methods, management and salinity of irrigation water on tomato yield, soil moisture and salinity distribution. *Irrig. Sci.* (26), 313–323.
17. Marcus, H. and B. d. Richard. 2012. Measuring Soil Salinity. Article in *Methods in molecular biology* (Clifton, N.J.) · August 2012. DOI: 10.1007/978-1-61779-986-0_28 · Source: PubMed.
18. Ministry of Agriculture and Land Reclamation, Economic Affairs Sector (EAS), *Bulletin of the Agriculture Statistics*, 2016.
19. Nagaz, K., M. M. Masmoudi and N. Mechlia, 2012. Effects of deficit drip-irrigation scheduling regimes with saline water on pepper yield, water productivity and soil salinity under arid conditions of Tunisia. *Journal of Agriculture and Environment for International Development JAEID*, 106 (2): 85-103.
20. Navarro, J. M., C. Garrido, p. Flores and V. Martinez, 2010. The effect of salinity on yield and fruit quality of pepper grown in perlite. *Spanish journal of agri. Research* 8(1), 142-150.
21. Pascale, S. D., C. Ruggiero, G. Barbieri and A. Maggio, 2003. Physiological responses of pepper to salinity and drought. *J. Amer. Soc. Hort. Sci.* 128: 48-54.
22. Rameshwaran, P., A. Tepe, A. Yazar and R. Ragab, 2015. The effect of saline irrigation water on the yield of pepper: experimental and modelling study. *Irrig. Drain.* 64, 41–49.
23. Semiz, G. D., D. L. Suarez, A. Unlukara and E. Yurtseven, 2014. Interactive effects of salinity and N on pepper (*capsicum annum L.*) Yield, Water Use Efficiency and root zone and drainage salinity. *Journal of Plant Nutrition* (37)595–610.
24. Yildirim, E. and I. Guvence, 2006. Salt tolerance of pepper cultivars during germination and seedling growth. *Turk J Agric* 30: 347-353.

تأثير ملوحة مياه الري على محصول الفلفل وانتاجيته المائية تحت نظام الري بالتنقيط

فوزية أيمن نجم الدين² ، محمد يوسف الأنصاري¹ ،
منتصر عبدالله عواد¹، وائل محمود سلطان²

1. كلية الزراعة - جامعة بنها-مشتهر-مصر.
2. معهد بحوث الهندسة الزراعية - مركز البحوث الزراعية-الدقي - الجيزة - مصر.

أدت محدودية توافر مياه الري العذبة في مصر، إلى زيادة الطلب على استخدام المياه الجوفية المالحة للري خاصة في مناطق الاستصلاح الجديدة. لذلك أجريت تجربة حقلية على أرض رملية في محطة تجارب الزراعات المحمية بالدقي التابعة لوزارة الزراعة وإستصلاح الأراضي ، مصر خلال موسم صيف وشتاء 2017-2018 لدراسة تأثير ملوحة المياه تحت نظام الري بالتنقيط على إنتاجية محصول الفلفل (*Capsicum annum L. cv. Top star*) وكذلك على كفاءة استخدام المياه (الإنتاجية المائية للفلفل جم/م³ ماء) ، لذلك تم إختيار معاملات ري بتركيزات ملوحة مختلفة التوصيل الكهربائي (الري بماء عذب بتركيز 0,4 ملليموز/سم (كنترول) والري بماء مالح تركيز 3 ملليموز/سم و الري بماء مالح 5 ملليموز/سم). وتمت عملية تقدير وإضافة الإحتياجات الغسيلية وفقا للمعادلات المتعارف عليها والتركيزات الملحية لكل معاملة. وأظهرت النتائج أنه كلما إرتفعت درجة التوصيل الكهربائي لماء الري المستخدم كلما زاد تركيز الأملاح في التربة وبالتالي يؤدي ذلك إلى عدم قدرة النبات على إمتصاص الماء والعناصر الغذائية من التربة وبالتالي إنخفاض الإنتاجية. كما بينت النتائج أنه كلما زاد تركيز الأملاح في ماء الري ، كلما إنخفض كل من إرتفاع النبات ، الوزن الرطب للجذور ، وعدد البذور داخل الثمرة. كانت أفضل إنتاجية سجلت مع الري بمعاملة الكنترول وإضافة 10% إحتياجات غسيلية (2.982 كجم/م²) وأيضا أفضل كفاءة إنتاجية للمياه (0.685 كجم/م³) ، في حين أن الري بماء 3 مموز/سم و5مموز/سم مع إضافة الإحتياجات الغسيلية أحدث إنخفاض في الإنتاجية مقداره 19% و 79.4% على التوالي بالمقارنة بالري بماء الكنترول.