Effect of salt stress on greenhouse cucumber root distribution and root tolerance index in hydroponics cultivation

Sanaz Yazdani[1], Abd Ali Naseri [2], Abdol Rahim Hooshmand [3], Naser Alemzadeh Ansari[4]

[1.] Msc Student of irrigation and drainage, Shahid Chamran University of Ahvaz
[2.] Professor, Department of Water Engineering, Shahid Chamran University of Ahvaz
[3.] Associate Professor, Department of Water Engineering, Shahid Chamran University of Ahvaz
[4.] Associate Professor, Department of Horticulture, Shahid Chamran University of Ahvaz.
Yazdani_sanaz@ymail.com

Abstract: The current research was done in a hydroponic culture during fall and winter in 2016 in a research greenhouse in Shahid Chamran Agricultural university of Ahwaz. The purpose of the study was to understand the effect of Irrigation water salinity on root distribution and root tolerance index of greenhouse cucumber including root length, root width, root volume, and root tolerance index. The irrigation was done by drip irrigation. The applied irrigation treatments were included three water need levels of 2.5, 3.5 and 4.5 ds/m which were performed in a randomized complete design. The results of the research showed that salt stress had a significant effect on root length in the level of 1% but had no significant effect on root volume, rot width and root resistance index. It can be concluded that we can use low quality water and nutrient solution of EC=4.5ds/m in regions which lacks high quality water to save fresh water.

[Sanaz Yazdani, Abd Ali Naseri, Abdol Rahim Hooshmand, Naser Alemzadeh Ansari . **Effect of salt stress on greenhouse cucumber root distribution and root tolerance index in hydroponics cultivation.** *Rep Opinion* 2017;9(10):17-20]. ISSN 1553-9873 (print); ISSN 2375-7205 (online). http://www.sciencepub.net/report. 4. doi:10.7537/marsroj091017.04.

Keywords: Cucumber; Root; Hydroponic Culture; Water Stress

1. Introduction

Greenhouse cucumber is a fast growth plant which grows in wet and warm weather. Sufficient water in soil is necessary for vegetative growth and consequently for photosynthetic capacity (Ortega & Kishman, 1982). Among cucurbits, cucumber is in the group of cash products in the classification of crops. Thus produced cucumber is supplied as the end product in the market and its period of return of capital is very short (Sadrghaen, 2002). In addition, considering the extensive facilities of production and processing of this crop in Iran, the crop is economically important and also attracts agricultural officials' attraction, because it causes importing of currency in the country (Mehrabi, 2008).

Salt stress is the main environmental stress following water stress which affects the plants and reduce the growth of plants sensitive to salinity. On the other hand, it is impossible to solve the problems of plant growth by correct irrigation management. Thus, it is necessary to do some researches about plants which can grow on salt soil. Salinity effects on plants by increasing the osmotic pressure, ion poisoning and malnutrition. Different chemical compounds reduce the plant growth in the same osmotic pressure (Homae, 2002). On the other hand, as the concentration of definite salt goes beyond a limit in soil solution or the current ion ratios change in favor of one of them, ion poisoning and nutrition imbalance will occur and the degree of reduction of plant growth will be double (Pop et al, 1983).

Since studying the root behavior is generally difficult, time consuming and approximate, using hydroponic culture and creating stress by adding salt is an easy solution for controlling the root behavior against stress and it also answers most of the question about the relationship between water and root. Aboromman et al, (2013) investigated the effect of phosphor in cucumber root micronutrient on reducing salinity stress and showed that dry and wet weight of aerial part and root, height of aerial part, and root length decrease significantly by salinity of irrigation water. Hosseini et al, (2016) investigated the effect of mycorrhiza fungi on cucumber pythium damping off under the salinity stress condition and measured the root length; stem height, wet and dry weight of root and aerial part. They asserted that different features reduce at the level of 5 % in response to salinity.

2. Material and Methods

The research has been done in research greenhouse of Chamran Agricultural University, Ahwaz during fall and winter in 2016 to investigate the effect of water stress on the distribution of the root of greenhouse cucumber such as root length, root width, root volume and root tolerance index in hydroponic culture. The experiment was performed in randomized complete design with employing of 3 irrigation treatments and 5 replications. Since the losses such as evaporation, depth penetration and… are low, irrigation treatments were performed in three water need levels of 2.5 ds/m (S_1) as the control, 3.5ds/m (S_2) and 4.5ds/m (S_3).

2.1 Seed bed and Fertilizer

the used pots were plastic and white with the large and small diameters of 24cm and 20cm and height of 25cm. An equal amount of gravel was poured on the bottom of the pots (for drainage) and then pots were filled with cocopeat and perlite with ratio of 50:50.

The nutrient solution used in this research was provided based on the rash nutrient formula (table 1). Before planting, cucumber seeds were soaked in petri dish containing filter paper in the room temperature and after 24 hours were planted in small pots of 120cc (paper cups) in cocopeat perlite cultures (50:50). After 10 days, seedlings were transplanted to the pots. The pruning was done to let the length growth and produce high quality fruit near the main stem and also improve the air conditioning and facilitate the harvest. The pruning was in form of one shoot and subshrubs were eliminated gradually. Thus, all the produced energy of the plant is used for the growth of leaf and stem and consequently the plant will be strong. Deficit irrigation treatments were performed on the bushes on November 6th in 2016.

Table 1. compound of proposed rash nutrient solution (2005) of greenhouse cucumber

Consuming elements	Element concentration (ppm)	low consumption elements	Element concentration (ppm)
N	140	Mn	0.8
P	50	CU	0.07
K	350	Zn	0.1
Mg	50	B	0.3
Ca	200	MO	0.03
S	150	Fe	3

2.2 Greenhouse condition and measuring tools

Cucumber grows in warm seasons and is sensitive to cold weather especially to temperature under 15°C. Thus, the relative moisture and temperature inside and outside of the greenhouse measured daily. Table 2 presents maximum, minimum and average temperature and also the relative moisture inside the greenhouse.

Table 2. temperature variables and relative moisture inside the greenhouse

Variable / Month	relative moisture	Temperature (°C)		
		Average	Maximum	Minimum
October	46.15	26.07	35	17
November	45.86	21.23	30.67	11.69
December	50.8	22.59	31	14.18
January	46.83	22.37	31.08	13.68
February	47.64	22.5	30.6	14.4

To measure the length and depth of the root, we put the roots on a flat surface and measure them by a ruler. Root volume was measured by liquid movement. For doing so, first an exact volume of water was poured in the beaker, and then the root was put in the beaker, the amount of water which rose is considered as the root volume. Root tolerance index was calculated as follows based on the root dry weight in stress and without stress condition (Maiti et., al 1996).

$$TI = \frac{W1}{W2} \quad (1\text{-}1)$$

TI: root tolerance index

W_1: root dry weight in stress condition

W_2: root dry weight in without stress condition

2.3 Irrigation management

An automatic irrigation system was designed for doing the experiment. For doing the irrigation and transferring the nutrient solution, three polyethylene 100 liter capacitors were used for making salt water which was connected to polyethylene 3/4 tube by metal socket and connector. 0/5 pump was used for transferring water and then, 3/4 tube was connected to the pump by polyethylene 3/4connector and the pump was balanced. Solenoid valve used for pump output in order that nutrient solution outflows just at the time of irrigation and water enters the system just when is necessary. After the output of solenoid valve, an output returns to the reservoir to set the pressure. Netafim drip pan and 16 mm tube were used for setting the irrigation volume and avoiding higher pressure. Water output was divided in to three separated lines by metal connectors to do the irrigation treatments and transferred to each line by using plastic 1/2 valve of drip irrigation to polyethylene lateral 16 mm tube and Netafim drip pan. Drip pans were placed on laterals in the distance of 0.5m.

Irrigation started by command of timer to solenoid valve and pump, and the volume of irrigation was set by regulating the return valve and the valves of each lateral line. To determine the output water volume, a dish was put under each drip pan to shows the amount of poured water and also the pressure on each drip pan on that time. Then, pots put under laterals in a way that drip pans were backed to bushes to avoid direct pouring of nutrient solution into the bushes and also damaging the bushes.

2.4 data analysis

The design of the data was in form of split plot experiment and randomized complete design. Data were analyzed by SPSS software and Duncan test in the level of 5%. Excel software was used for depicting the diagrams.

3. Results

Table 3 shows the variance analysis results of salinity stress effect on studied characteristic of cucumber.

Table 3- analysis results of salinity effect

S.O.V	df	Mean of Squares			
		Root length	root width	root volume	root tolerance index
salinity	2	39.2006**	1.5226**	0.294n.s	0.003**
Error	12	5.4940	0.4260	1.8039	0.002
CV %		5.54	2.75	8.25	4.19

**,* and n.s show the meaningfulness in the level of 1% and 5% and meaningless, respectively.

3.1 Effect of water stress on root length

According to table 3 data the effect of salinity on root length was meaningful at the level of 1 percent. Root length decreases by salinity stress and if the level of salinity stress increases, root length will decrease (figure 1). There was no significant difference regarding root length between salinity levels of 1st and 2nd and also between 2nd and 3rd level but there was a significant difference between the levels of 1st and 3rd at the level of 5 percent. There was a significant difference among different salinity levels regarding with root length of cucumber at the level of 5 percent in the researches of Hosseini et al, (2016) and Aboromman et al, (2013). These results correspond to the results of our research.

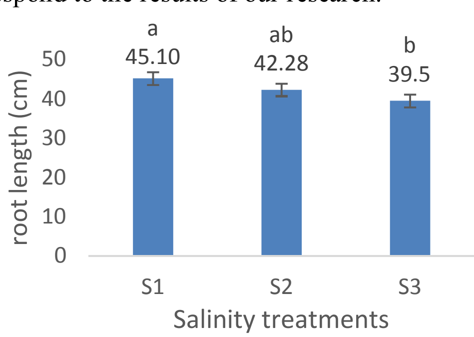

Figure 1. Effect of Salinity stress on root length

3.2 Effect of salinity stress on root width

These results correspond to the results of our research. According to data (table 3) the effect of salinity was not significant on root width. Root width of the plant reduced after applying salinity stress but the decrease was not significant (figure 2). There's no significant difference in root width among different levels of salinity.

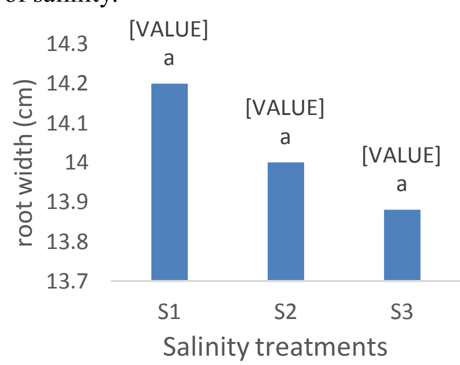

Figure 2. Effect of Salinity stress on root width

3.3 Effect of salinity stress on root volume

These results correspond to the results of our research According to data (table 3) the effect of salinity was not significant on root volume. Root volume of the plant reduced after applying salinity stress but the decrease was not significant (figure 3). There's no significant difference in root volume among different levels of salinity.

The results of Shafi et al, (2010) research showed that salinity stress decrease the total volume of the root which contradicted to obtaining results, probably because salinity effects root length and not root width.

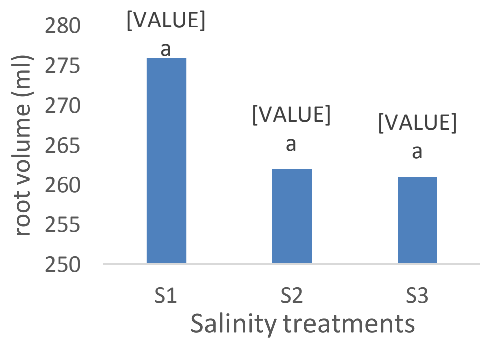

Figure 3. Effect of Salinity stress on root volume

3.4 Effect of salinity stress on tolerance index

According to the results (table 3) the effect of salinity on root tolerance index was not significant. Root tolerance index reduced because of salinity stress in nutrient solution, but the reduction was significant. There was no significant difference among different levels of salinity regarding with root tolerance index.

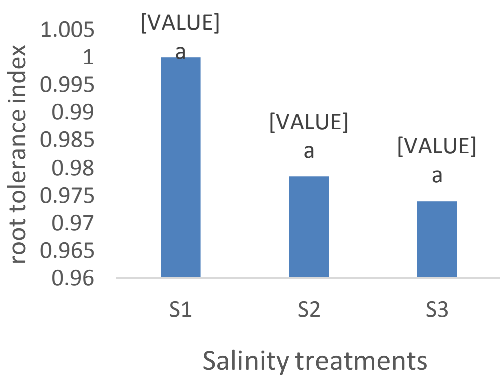

Figure 4. Effect of Salinity stress on root tolerance index

4. Discussions

The results of the research have shown that control treatment had the highest root distribution and S_3 had the lowest root distribution, but salinity stress had a significant effect on root length and had no significant effect on root volume and width and also on root resistance index. It can be concluded that we can use low quality water and nutrition solution of EC=4.5ds/m in areas which lack high quality water to save fresh water.

Corresponding Author:
Sanaz yazdani
Student of Irrigation and Drainage
Faculty of Water Sciences Engineering
Shahid Chamran University of Ahvaz
Ahvaz, Iran
Telephone: +98-939-533-4814
Email: Yazdani_sanaz@ymail.com

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10/16/2017