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# TOMATO YIELD RESPONSE TO SALT STRESS DURING DIFFERENT GROWTH STAGES UNDER ARID ENVIRONMENTAL CONDITIONS

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## ABSTRACT

Field experiment in calcareous sandy clay loam soil at Maryout Experimental Station Farm, Desert Research Center, Egypt during summer season 2007 were conducted to investigate growth parameters and fruit yield of tomato (*Lycopersicon esculentum, mill*., cultivator 888) response to salt stress at irrigation water levels during different growth stages under drip and gated-pipe irrigation systems in arid environmental conditions. Each irrigation system is comprised 9 irrigation treatments combined between salt stress using well water of 9.15 $dSm^{-1}$ and irrigation water levels of 100, 75, and 50 % from crop evapotranspiration (ETc) subjected during development, flowering and harvesting stages as well as control treatment; the plants were irrigated by the irrigation water level of 100 % ETc during the season using agricultural drainage water of 2.80$dSm^{-1}$.Under studied irrigation systems, the plant height, fresh, dry weight and fruit yield of tomato plants at the harvesting subjected to salt stress using 9.15 $dSm^{-1}$ and irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting growth stages were significantly decreased by decrement irrigation water levels. However, the results revealed that the tomato leaf water potential values as affected by the studied salt stress at irrigation water levels of % ETc was appeared opposite trend that obtained for the other growth parameters and fruit yield. Also, the results showed that the plant height, fresh, dry weight, leaf water potential and fruit yield of tomato plants at the harvesting stage subjected to studied salt stress and irrigation water depth levels during development, flowering and harvesting growth stages under drip irrigation system, in general were higher than that obtained under gated pipe irrigation system. Under drip irrigation system, fruit yield reduction percentages relative to control treatment were 9.9, 16.0 & 22.5 % for plants subjected during development stage, 21.5, 28.8 & 41.5 % for plants subjected during flowering stage and 11.6, 16.2 & 23.2 for plants subjected during harvesting stage at irrigation water levels of 100, 75 and 50 % ETc by well water, 9.15 $dSm^{-1}$, respectively. Under gated pipe irrigation system, fruit yield reduction percentages were 11.6, 13.7&16.8 % for plants subjected during development stage, 20.6, 22.2 & 29.1 % for plants subjected during flowering stage and 13.2, 14.2 & 17.7 for plants subjected during harvesting stage at irrigation water levels of 100, 75 and 50 % ETc by well water, 9.15 $dSm^{-1}$, respectively. Consequently, the development growth stage of tomatoes subjected to applied irrigation water levels of 100, 75 and 50 % ETc by well water, 9.15 $dSm^{-1}$, is the lowest stage affected than other growth stages while, the flowering growth stages of tomatoes is more affected to salt stress and deficit irrigation water amount than other growth stages especially at irrigation water level of 50 % ETc, under studied irrigation systems in environmental conditions.

**Keywords:** salt stress, drip irrigation, gated pipe irrigation, growth stages, tomato growth parameters, tomato fruit yield

# INTRODUCTION

The increasing demand for water resources in the world, especially in the arid and semi-arid regions has forced farmers to use low quality water for irrigation such as agricultural drainage water and marginal quality ground water. The use of these low qualities in the irrigation is depending on the total salt concentration, irrigation water depth, soil properties, climate, irrigation system, crop, fertilization, plant growth stages and time use of the applied irrigation water during the growing season. Baker and Rosenqvist (2004) reported that the initial effects of increasing soil salinity are very similar to those observed when plants exposed to drought. Also, Katerji *et al*., (1998) studied the effect of tomato growth under both water and salt stresses and they reported that the behavior of the tomato plant under saline conditions appears to be similar to that under drought conditions. On the other hand Al-Mohammadi and Al-Zu'bi (2011) conducted an experiment under greenhouse conditions to evaluate the optimum combination of irrigation and fertilizer levels to attain the best yield and quality of tomato crop, and concluded that the irrigation and fertilizer levels had significant effects on the number of flowers per plant; however, plant height was not affected significantly by any treatment.

Hajer, *et al*., (2006) studied the effect of water salinity (1500, 2500 and 3500 ppm) on the growth of tomato (*Lycopersicon esculentum*) and reported that stem height decreased with increasing salinity, moreover the reduction of plant height was significant at four weeks until the end of the experiment. Furthermore, it was clear that there is a pronounced increase in the plant height with time in plants under saline conditions and great increase in the plant height of control.

Yurtseven, *et al*., (2005) effectuated an experiment to study the effects of four irrigation water salinities of 0.25, 2.5, 5 and 10 $dSm^{-1}$ on some quality parameters of a native Central Anatolian tomato species (*Lycopersicon esculentum*) under greenhouse conditions and reported that tomato biomass affected only by the salinity levels of the irrigation water. Where the biomass decreased with increasing salinity and increasing salinity levels resulted in smaller fruit size and higher soluble solid content. On the other hand, Shannon, *et al*., (1987) found that salinity adversely affected the vegetative growth of the tomato, and it reduced fresh and dry shoot and root weight. Al-Rwahy (1989) concluded that the reduction of tomato dry weights due to increased salinity might be a result of a combination of osmotic and specific ion effects of Cl and Na.

Olympios *et al*., (2003) used four levels of salinity in the irrigation water (1.7 (control), 3.7, 5.7 and 8.7 $dSm^{-1}$) applied to tomato plants at various growth stages and for different time duration. Salinity negatively affected the plant size and total fruit weight: the higher the concentration, the lower the growth and yield. Moreover fruit number was significantly reduced only at 8.7 $dSm^{-1}$. The average fruit weight was reduced at the highest salinity especially when applied at an early growth stage. When the salinity stress was applied during the entire growing period, the negative results were higher, with increasing reduction in yield occurring with the increase in salt concentration.

Babu, *et al*., (2012) studied salt stress on tomato crop (25, 50, 100, 150 and 200 mM NaCl). They found that leaf area and dry matter content of tomato fruits decreased with application of elevated salt stress. Application of NaCl caused increase in $Na^+$ content, while $K^+$ content and $K^+/Na^+$ ratio decreased with increase in salt stress. Another striking point is that increase in proline and $Na^+$ content was more in leaves than fruits, which suggests that leaves are more sensitive than fruits.

Boamah, *et al*., (2011) in this research was conducted to determine the salinity level of irrigation water from a dug well (0.07 $dSm^{-1}$), pond (0.25 $dSm^{-1}$) and tap water (0.02 $dSm^{-1}$) as well as its effect on the yield of a tomato crop. The flowering and yield of tomato was high with crops treated with well water (45.22%; 99.08 kg/ha) followed by the pond, (27.70%; 43.76 kg/ha) and tap water (27.08%; 27.25 kg/ha) in that order. There was no significant difference in flowering and in yield of crops between the tap and pond treatments at both 0.05 and 0.01 levels but there was a significant difference in yield between the well treated crops and other sources.

On the other hand, Malash *et al*., (2005) effectuated a field experiment to study the effect of two water management strategies; i.e. alternate and mixed supply of fresh (canal water (0.55 $dSm^{-1}$) and saline (drainage water (4.2 – 4.8 $dSm^{-1}$) water in six ratios applied using drip and furrow irrigation methods on tomato (cv. *Floradade*) yield and growth. They also investigated the salt concentration in the root zone were investigated in the Nile Delta, Egypt. Drip irrigation enhanced tomato growth more, early in the growing season, than did furrow irrigation, but at later stages, there was little difference between the two irrigation systems. Drip irrigation, however, gave higher yield. Regardless, the irrigation method, mixed water management practice gave higher growth and yield than alternate irrigation. Moreover, growth and yield were high in alternate practice only with fresh water, whereas moderate saline irrigation waters in mixed practice gave the highest values of yield and growth. Thus, the highest yield obtained (3.2 kg/plant) was the result of the combination of drip system and mixed management practice using a ratio of 60% fresh water with 40% saline water. There was a strong negative relationship between tomato yield and seasonal average of electrical conductivity of the soil solution. Abdel-Gawad *et al*., (2005) mentioned that irrigating tomato using drip irrigation system produces higher yield than the traditional surface irrigation method. Moreover, saline irrigation water having an EC of 8 $dSm^{-1}$can produce about 50% the yield of that grown under non-saline condition, when an additional leaching fraction of 15% applied with the irrigation water.

The objectives of the present study are to investigate the tomatoes fruit yield and some growth parameters response to salt stress with different irrigation water depth levels subjected during some growth stages under drip and gated-pipe irrigation systems in arid environmental conditions.

## MATERIALS AND METHODS

Field experiment was carried out at Maryout Experimental Station Farm, Desert Research Center Egypt during 2007 summer season. The station located at 30° 55' 71″ N, 29° 51' 67" E and 50 m above sea level. The experiment amid to study the impact of salt stress subjected during different growth stages at different irrigation water depth levels on growth parameters as well as tomato yield under drip and gated pipe irrigation systems. The soil was classified as calcareous sandy clay loam (59 % sand, 13 % silt and 28 % clay) with 29.50 % total calcium carbonate and 1370 $Mg/m^3$ bulk density. Particle size distribution was determined by pipette method accordingly Kulte (1986). Total carbonate was determined as $CaCO_3$ % by using Collin's Calcimeter described as Jackson (1967) while the bulk density was determined by core method accordingly Kulte (1986). The electric conductivity of soil paste extract value (ECe) was 2.13 dS $m^{-1}$ and soil reaction, pH, value of 8.2 as well as sodium adsorption ratio (SAR) value of 2.35. Thus, the soil is non saline and non alkali. Soil salinity (ECe) as total soluble salts were determined in the soil saturation extract, Richards (1954). Soil reaction (pH) was measured in soil paste using pH meter according to Page (1982).

Tomato seeds (*Lycopersicon esculentum, mill*., cultivator 888) planted in seedling plats, filled mixture of peat moss and vermiculite. Anti-fungi used to prevent fungus growth in the planting media. The plates were irrigated with fresh water (0.4 dS/m) to have good establishment. Some nutrients solutions used to encourage seeds growth. Seeds were planted in the plates on 1$^{st}$ April and after 30 days from the planting date, the seedlings transported to the field calcareous sandy clay loam soil. Land preparation before planting ploughed and mixed with mono calcium phosphate with a rate of 480 kg/ha. Different treatments were carried out after one week from the transporting date and the date of harvesting was on 24$^{th}$ August. The agronomic practices including weed and pest control followed as recommended tomato production. It includes: During the growing season, N fertilizers applied with a rate of 280 kg N/ha, and K fertilizers with a rate of 175 kg K/ha. Mixer of $FeSO_4$, $MnSO_4$, $ZnSO_4$, and $CuSO_4$ applied as foliar spray.

The layout of the experiment was a completely randomized design with three replicates. Drip and gated pipe irrigation systems were used in this investigation. For drip irrigation systems, the main irrigation line was 63 mm, and the sub main lines were 16 mm in diameter; the length of sub main lines was 9 m. The space between plants was 0.5 m with distance between rows of 1 m. Furthermore, water meters were installed for measuring the amount of applied irrigation water for each treatment. The two irrigation water qualities used in the experiment. The first one was agricultural drainage water of 2.80 $dSm^{-1}$ and 12.15 SAR for irrigated the control treatment and the second was well water of 9.15 $dSm^{-1}$ and 15.25 SAR used as salt stress for the other treatments. The time of salt stress by well water was subjected during development, flowering and harvesting of plant growth stages. The applied irrigation water depth included of 3 levels of crop evapotranspiration (ETc) of 100, 75 and 50 %.

**Table (1): Meteorological data and reference crop evapotranspiration (ETo) mm/day of Maryout Research Station, Desert Research Center.**

| Month | Max. T. ºC | Min. T. ºC | Humidity % | Wind speed km/day | Sunshine H | *ETo mm/day |
|---|---|---|---|---|---|---|
| Jan | 17.5 | 7.5 | 70.0 | 343.0 | 6.6 | 2.46 |
| Feb | 17.5 | 7.5 | 70.0 | 343.0 | 7.6 | 2.70 |
| Mar | 22.5 | 12.5 | 60.0 | 354.2 | 8.3 | 4.30 |
| Apr | 25.0 | 12.5 | 60.0 | 334.4 | 9.2 | 5.10 |
| May | 27.0 | 15.0 | 60.0 | 311.0 | 10.4 | 5.73 |
| Jun | 30.0 | 20.0 | 60.0 | 311.0 | 11.9 | 6.68 |
| Jul | 30.0 | 22.5 | 60.0 | 338.7 | 12.0 | 6.86 |
| Aug | 37.0 | 25.0 | 60.0 | 337.0 | 11.3 | 7.73 |
| Sep | 33.0 | 24.0 | 60.0 | 334.4 | 10.7 | 6.63 |
| Oct | 28.5 | 20.0 | 60.0 | 337.8 | 9.2 | 5.09 |
| Nov | 25.0 | 19.0 | 62.0 | 338.7 | 7.4 | 3.92 |
| Dec | 21.0 | 14.0 | 70.0 | 342.1 | 6.5 | 2.79 |

**ETo was calculated according to CROPWAT 8.0 computer program using Penman Monteith equation.**

**Table (2): Crop water requirement, ETc, of tomatoes subjected to salt stress of 9.15 dSm$^{-1}$at irrigation water levels during development, flowering and harvesting growth stages.**

| Irrigation treatment | ETc, mm/growth stage | | |
|---|---|---|---|
| | Growth stage | | |
| | Development | Flowering | Harvesting |
| T1 (Control) | 125.46 | 350.66 | 180.65 |
| $T_2$100 – D | 125.46* | 350.66 | 180.65 |
| $T_2$100 – F | 125.46 | 350.66* | 180.65 |
| $T_2$100 – H | 125.46 | 350.66 | 180.65* |
| $T_4$75 – D | 94.10* | 350.66 | 180.65 |
| $T_4$75 – F | 125.46 | 263.00* | 180.65 |
| $T_4$75 – H | 125.46 | 350.66 | 135.49* |
| $T_4$50 – D | 62.73* | 350.66 | 180.65 |
| $T_4$50 – F | 125.46 | 175.33* | 180.65 |
| $T_4$50 – H | 125.46 | 350.66 | 90.33* |

*** The tomato plants subjected to salt stress of 9.15 dSm$^{-1}$ at irrigation water levels during different growth stages.**

Crop water requirement was calculated using CROPWAT 8 computer program using Penman-Monteith equation with the meteorological data of Maryout Experimental Station (Table1).The duration of tomatoes stages and the crop factor of these stages were 35, 45 and 30 days and 0.60, 1.15 and 0.80 for development, flowering and harvesting growth stages respectively, according to Allen, *et al*., (1998). The data in Table (2) show the irrigation water depth levels and the time of salt stress subjected during development, flowering and harvesting growth stages. Each irrigation system consisted of

10 treatments combined between applied irrigation water depth levels and salt stress during the different growth stages as follows:

- $T_1$100 (control): the plants were irrigated by the applied irrigation water depth level of 100 % ETc during the season using drainage water, 2.80 $dSm^{-1}$.
- $T_2$100 –D:the plants were irrigated by the applied irrigation water depth level of 100 % ETc using well water, 9.15 $dSm^{-1}$,subjected during the development stage and applied the same water depth using drainage water, 2.80 $dSm^{-1}$, during the other growth stages.
- $T_3$100 – F: the plants were irrigated by the applied irrigation water depth level of 100 % ETc using well water, 9.15 $dSm^{-1}$, subjected during the flowering stage and applied the same water depth using drainage water, 2.80 $dSm^{-1}$, during the other stages.
- $T_4$100 – H: the plants were irrigated by the applied irrigation water depth level of 100 % ETc using well water, 9.15 $dSm^{-1}$, subjected during the harvesting stage and applied the same water depth using drainage water, 2.80 $dSm^{-1}$, during other growth stages.
- $T_5$75 – D: the plants were irrigated by the applied irrigation water depth level of 75 % ETc using well water, 9.15 $dSm^{-1}$, subjected during the development stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$,during other growth stages.
- $T_6$75 – F: the plants were irrigated by the applied irrigation water depth level of 75% ETc using well water, 9.15 $dSm^{-1}$, subjected during the flowering stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$,during other growth stages.
- $T_7$75 – H: the plants were irrigated by the applied irrigation water depth level of 75 % ETc using well water, 9.15 $dSm^{-1}$, subjected during the harvesting stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$, during other growth stages.
- $T_8$50 – D: the plants were irrigated by the applied irrigation water depth level of 50 % ETc using well water, 9.15$dSm^{-1}$, subjected during the development stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$,during other growth stages.
- $T_9$50 – F: the plants were irrigated by the applied irrigation water depth level of 50 % ETc using well water, 9.15 $dSm^{-1}$, subjected during the flowering stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$, during other growth stages.
- $T_{10}$50 – H: the plants were irrigated by the applied irrigation water depth level of 50 % ETc using well water, 9.15$dSm^{-1}$, subjected during the harvesting stage and applied the irrigation water depth of 100 % ETc using drainage water, 2.80 $dSm^{-1}$, during other growth stages.

The plant height, cm, the plant fresh and dry weight (g/plant) was determined at the harvesting. The leaf water potential, - kPa, was determined with a portable pressure chamber apparatus (Soil Moisture Equipment Corp, Santa Barbara, CA, USA) for predawn using the fourth leaf in the plant at the harvesting. Fruit tomato yield in kg/ plant was determined at the harvesting.

Analysis of variance by 2 Way Completely Randomized was used to test the degree of variability among the obtained data. Least significant difference (LSD) test was used for the comparison among treatments means, Steel and Torrie (1980). CoHort computer program was used for the statistical analysis, version 6.400.

## RESULTS AND DISCUSSION

**Plant height**

The obtained results revealed that plant height values (cm) of tomatoes at the harvesting subjected during to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting stages under drip irrigation system generally non significantly higher than that obtained under gated pipe irrigation system, Table (3) and Fig.(1). With exception that plant height values for the plants subjected to salt stress at irrigation water depth levels during the development stage, the value for the plants subjected to salt stress at irrigation water level of 100 % ETc during the flowering stage and control treatment under drip irrigation system were low. This lower may be attributed to increase salt accumulation in soil of active root zone under drip irrigation system more than that obtained gated pipe irrigation system. These results are confirmed with Hajer, *et al*. (2006). Under studied irrigation systems, plant height values of tomatoes at the harvesting subjected to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting stages were significantly decreased with decrement irrigation water depth levels % ETc, Table(3) Fig.(1).This decrease in plant height may be attributed to mainly the harmful salinity effects of soil at active root zone resulted by using irrigation water by well water, 9.15 $dSm^{-1}$, and deficit irrigation water. Under drip irrigation system, decrease percentage of plant height values relative to control treatment were 14.3, 26.7 & 39.3% for the subjected plants during development stage, 5.5, 16.1 & 25.7 % for the subjected plants during flowering stage and -3.3, 12.7 & 19.5 % for the subjected plants during harvesting stage by well water, 9.15 $dSm^{-1}$, at irrigation water depth levels of 100, 75 and 50 % ETc, respectively. Under gated pipe irrigation system, decrease percentage relative to control treatment were 10.0, 19.2 & 39.0 % for the subjected plants during development stage,3.8, 18.2 & 28.0 % for the subjected plants during flowering stage and 3.8, 14.1& 22.8 % for the subjected plants during harvesting stage by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc, respectively. Under studied irrigation systems, consequently, the development growth stage of tomatoes subjected to studied irrigation water levels by well water; 9.15 $dSm^{-1}$, is more affected than other growth stages, especially at irrigation water depth level 50 % ETc under studied irrigation system in environmental conditions. These results are in agreement with Olympios *et al*. (2003).

**Fig 1**

**Table(3):Plant growth parameters and fruit yield of tomatoes at the harvesting growth stage subjected to salt stress of 9.15 $dSm^{-1}$ at irrigation water levels during different growth stages under studied irrigation systems.**

| Irrigation treatment | Plant height cm | Fresh weight g/plant | Dry weight g/plant | Leaf water potential - kPa | Fruit yield kg/plant |
|---|---|---|---|---|---|
| Drip irrigation system | | | | | |
| Control | 64.56 | 411.97 | 103.76 | 8.27 | 4.75 |
| $T_2$100 – D | 55.33 | 345.70 | 72.33 | 7.70 | 4.28 |
| $T_3$100 – F | 61.00 | 327.07 | 108.20 | 9.00 | 3.73 |
| $T_4$100 – H | 66.67 | 354.07 | 99.27 | 11.50 | 4.20 |
| $T_5$75 – D | 47.33 | 276.70 | 63.37 | 13.20 | 3.99 |
| $T_6$75 – F | 54.17 | 266.43 | 88.67 | 16.70 | 3.38 |
| $T_7$75 – H | 56.33 | 321.07 | 82.47 | 16.30 | 3.98 |
| $T_8$50 – D | 39.17 | 193.70 | 53.30 | 17.70 | 3.68 |
| $T_9$50 – F | 48.00 | 258.20 | 66.93 | 18.30 | 2.78 |
| $T_{10}$50 – H | 52.00 | 246.63 | 63.53 | 19.80 | 3.65 |
| Average | 54.49 | 303.49 | 80.22 | 13.84 | 3.83 |
| Gated pipe irrigation system | | | | | |
| Control | 64.78 | 355.87 | 97.39 | 7.53 | 4.23 |
| $T_2$100 – D | 58.33 | 291.63 | 69.43 | 8.50 | 3.74 |
| $T_3$100 – F | 62.33 | 318.83 | 104.80 | 8.70 | 3.36 |
| $T_4$100 – H | 62.33 | 323.27 | 95.93 | 9.70 | 3.67 |
| $T_5$75 – D | 52.33 | 252.00 | 58.07 | 15.30 | 3.65 |
| $T_6$75 – F | 53.00 | 273.90 | 90.30 | 15.20 | 3.29 |
| $T_7$75 – H | 55.67 | 278.63 | 81.94 | 17.50 | 3.63 |
| $T_8$50 – D | 39.50 | 171.80 | 36.23 | 17.50 | 3.52 |
| $T_9$50 – F | 46.67 | 196.77 | 44.53 | 18.50 | 3.00 |
| $T_{10}$50 – H | 50.00 | 198.37 | 42.43 | 19.30 | 3.48 |
| Average | 54.46 | 266.11 | 73.59 | 13.77 | 3.56 |
| $LSD_{05}$ Irrigation system, n = 30 | 1.15 | 12.49 | 3.78 | 0.41 | 0.12 |
| $LSD_{05}$ Irrigation treatment, n = 6 | 2.58 | 27.93 | 8.44 | 0.91 | 0.26 |

**Plant fresh weight**

In general under drip irrigation system, the fresh weight values (g/plant) of tomatoes at the harvesting subjected during to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting stages were significantly higher than that obtained under gated pipe irrigation system at the same water levels, Table (3) and Fig.(2). These results are in harmony with Yurtseven, *et al*. (2005). Under studied irrigation systems, tomato fresh weight values at the harvesting subjected to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting stages in general were significantly decreased with deceasing irrigation water levels, Table (3) and Fig.(2). This decrease in fresh weight values of tomato might be attributed to mainly the harmful salinity effects of soil at active root zone resulted by decreased irrigation water levels by well water, 9.15dSm$^{-1}$. Under drip irrigation system, decrease percentage of tomato fresh weight relative to control treatment were 16.1, 32.8 & 53.0 % for the subjected plants during development stage, 20.6, 35.3 & 37.3 % for the subjected plants during flowering stage and 14.1, 22.1 & 40.1 %, for the subjected plants during harvesting stage by well water, 9.15 dSm$^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc, respectively. While under gated pipe irrigation system, decrease percentage relative to control treatment were 18.1, 29.2 & 51.7 % for the subjected plants during development stage, 10.4, 23.0 & 44.7 % for the subjected plants during flowering stage and 9.2, 21.7 & 44.3 % for the subjected plants during harvesting stage by well water, 9.15 dSm$^{-1}$, at studied irrigation water levels of 100, 75 and 50 % ETc, respectively. In studied irrigation systems, the development growth stage of tomatoes subjected to studied irrigation water levels by well water, 9.15 dSm$^{-1}$, generally, is more affected than other growth stages; especially at water level 50 % ETc under studied irrigation system in environmental conditions.

**Plant dry weight**

Under drip irrigation system, generally, tomatoes dry weight values (g/plant), at the harvesting subjected to salt stress by well water, 9.15 dSm$^{-1}$, at irrigation water levels 100, 75 and 50 % ETc during development, flowering and harvesting stages were significantly higher than that obtained under gated pipe irrigation system, Table (3) and Fig.(3). Under studied irrigation systems, dry weight values of tomato plant at the harvesting growth stage subjected to salt stress by well water, 9.15 dSm$^{-1}$, at irrigation water levels 100, 75 and 50 % ETc during development, flowering and harvesting stages were significantly decreased with decreasing irrigation water levels by well water, 9.15 dSm$^{-1}$, Table (3) and Fig.(3). The decreasing tomato dry weight values may be attributed to the increasing salt accumulation in soil at active root zone resulted by the decrease of irrigation water levels using well water, 9.15 dSm$^{-1}$. Under drip irrigation system, decrease percentage of tomato dry weight values relative to control treatment were 30.3, 38.9 & 48.6 % for the subjected plants during development stage, - 4.3, 14.5 & 35.5 % for the subjected plants during flowering stage and 4.3, 20.5 & 38.8 %, for the subjected plants during harvesting stage by well water, 9.15 dSm$^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc, respectively. Under gated pipe irrigation system, the decrease percentage relative to control treatment were 28.7, 40.4 & 62.8 % for the subjected plants during development stage, -7.6, 7.3 & 54.3 % for the subjected plants during flowering stage and 1.5, 15.9 & 56.4 % for the subjected plants during harvesting stage by well water, 9.15 dSm$^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc, respectively. These results are in agreement with Al-Rwahy (1989). Thus, the development growth stage of tomatoes subjected to studied irrigation water levels by well water, 9.15 dSm$^{-1}$,is more affected than other growth stages under studied irrigation systems, especially at irrigation water level 50 % ETc under studied irrigation system in environmental conditions.

**Fig2**

**Fig 3**

**Leaf water potential**

The results in Table (3) and Fig.(4) revealed that tomatoes leaf water potential values, - kPa, at the harvesting subjected to well water, 9.15 $dSm^{-1}$, and irrigation water levels 100 and 50 % ETc during development, flowering and harvesting stages were non significantly higher under drip irrigation system than obtained under gated pipe irrigation system. Tomatoes leaf water potential values at the harvesting subjected to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels 100, 75 and 50 % ETc during development, flowering and harvesting growth stages were significantly increased by decreasing irrigation water levels by well water, 9.15 $dSm^{-1}$, Table (3) and Fig.(4). This increase in tomato leaf water potential values attributed to increasing soil salinity resulted by applied irrigation water using well water, 9.15 $dSm^{-1}$, and deficit of irrigation water amount. Under drip irrigation system, the leaf water potential values relative to control treatment were increased by 0.9, 1.6 & 2.1 times for the subjected plants during development, 1.1, 2.0 & 2.2 times for the subjected plants during flowering and 1.4, 2.0 & 2.4 times for the subjected plants during harvesting stages by well water, 9.15 $dSm^{-1}$ at irrigation water depth levels of 100, 75 and 50 % ETc, respectively. Under gated pipe irrigation system, the leaf water potential values relative to control treatment were increased by 1.1, 2.0 & 2.3 times for the subjected plants during development, 1.2, 2.0 & 2.5 times for the subjected plants during flowering and 1.3, 2.3 & 2.6 times for the subjected plants during harvesting stages using well water, 9.15 $dSm^{-1}$, irrigation water depth levels of 100, 75 and 50 % ETc respectively. Consequently, the harvesting growth stage of tomatoes subjected to well water, 9.15 $dSm^{-1}$, at studied irrigation water stress levels is more affected than other growth stages especially at irrigation water level 50 % ETc under studied irrigation system in environmental conditions.

**Total yield**

Although salt accumulation under drip irrigation system were higher than under gated pipe irrigation system, the fruit yield (kg/plant) of tomato plants subjected to salt stress by well water, 9.15 $dSm^{-1}$, at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting stages under drip irrigation system, in general were non significantly higher than that obtained gated pipe irrigation system, Table (3) and Fig. (5). Fruit yield of tomatoes somewhat were significantly reduced with decreasing irrigation water levels % ETc by well water, 9.15 $dSm^{-1}$,under drip irrigation system, especially at irrigation water depth level 50 % ETc. This reduction in fruit yield may be mainly attributed to the harmful salinity effects using highly saline irrigation water and deficit irrigation water amount.

Fig 4

Fig5

In this respect, many investigators found that increasing salinity of irrigation water and /or deficit of irrigation water depth are decreased the yield of tomatoes, Katerji *et al*. (1998), Olympios *et al*. (2003) and Yurtseven, *et al*., (2005). Under drip irrigation system, fruit yield reduction percentages relative to control treatment were 9.9, 16.0 & 22.5 % for subjected plants during development stage, 21.5, 28.8 & 41.5 % for subjected plants during flowering stage and 11.6, 16.2 & 23.2 for subjected plants during harvesting stage using well water, 9.15 $dSm^{-1}$, at irrigation water depth levels of 100, 75 and 50 % ETc, respectively. Under gated pipe irrigation system, fruit yield reduction percentages were 11.6, 13.7 & 16.8 % for subjected plants during development stage, 20.6, 22.2 & 29.1 % for subjected plants during flowering stage and 13.2, 14.2 &17.7 for subjected plants during harvesting stage using applied irrigation water levels of 100, 75 and 50 % ETc by well water, 9.15 $dSm^{-1}$, respectively. Consequently, the development growth stage of tomatoes subjected to applied irrigation water levels of 100, 75 and 50 % ETc by well water, 9.15 $dSm^{-1}$, is the lowest stage affected than other growth stages while, the flowering growth stage of tomatoes is more affected to salt stress and deficit irrigation water amount than other growth stages especially at irrigation water level of 50 % ETc, under studied irrigation system in environmental conditions.

## CONCLUSION

Under drip and gated pipe irrigation systems, the plant height, fresh, dry weight and fruit yield of tomato plants subjected to salt stress using 9.15 $dSm^{-1}$ at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting growth stages were significantly decreased by decrement studied irrigation water levels. However, the results revealed that the trend of tomatoes leaf water potential values affected by the studied salt stress at irrigation water levels of ETc was opposite trend that obtained for the other growth parameters and fruit yield. The data showed that the plant height, fresh, dry weight, leaf water potential and fruit yield of tomato plants subjected to salt stress using 9.15 $dSm^{-1}$at irrigation water levels of 100, 75 and 50 % ETc during development, flowering and harvesting growth stages under drip irrigation system, in general were higher than that obtained under gated pipe irrigation system. For fruit yield of tomato, the development growth stage of tomatoes subjected to applied irrigation water levels of 100, 75 and 50% ETc by well water of 9.15 $dSm^{-1}$, is the lowest affected than other growth stages and the flowering growth stage is more affected than other growth stages especially at irrigation water level of 50 % ETc, under studied irrigation system in arid environmental conditions.

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## استجابة نمو الطماطم للإجهاد الملحي ومستويات الري خلال مراحل النمو المختلفة تحت الظروف البيئية الجافة

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أجريت تجربة حقلية على محصول الطماطم في المزرعة البحثية لمحطة بحوث مريوط التابعة لمركز بحوث الصحراء – تمثل منطقة بيئية جافة خلال الموسم الصيفي 2007م. ويهدف البحث إلى استجابة عناصر المحصول وكذلك المحصول الكلي إلى تأثير الإجهاد الملحي تحت مستويات من الري تمثل 100، 75 و50 % من البخر– نتح أضيفت خلال مراحل النمو المختلفة تحت نظامي الري بالتنقيط والري السطحي المعدل ذو الفتحات. واستخدم في البحث صنف طماطم 888 (*Lycopersicon esculentum, mill.*) في تربة جيرية ذات قوام طميي طيني رملي– كل نظام الري يحتوي على 9 معاملات من الري مشتركة مع كل من الإجهاد الملحي باستخدام مياه بئر ذو ملوحة 9,15 ديسيمنز/م ومستويات الري 100، 75 و50 % من البخر – نتح خلال كل من مرحلة النمو، التزهير والحصاد بالإضافة إلى معاملة المقارنة وهى النباتات التي تم ريها بمستوى ري 100 % من البخر – نتح خلال موسم النمو باستخدم مياه الصرف الزراعي ذو ملوحة 2,8 ديسيمنز/م.

أظهرت النتائج أن طول النبات، الوزن الطازج، الوزن الجاف ومحصول الثمار لنباتات الطماطم عند الحصاد والتي تعرضت للإجهاد الملحي وعند مستويات الري خلال مراحل النمو المختلفة نقصت معنوياً مع نقص مستويات الري من البخر – نتح تحت نظامي الري تحت الدراسة. بينما أوضحت النتائج أن قيم الجهد المائي لورقة الطماطم والمتأثرة بالإجهاد الملحي وعند مستويات الري تحت الدراسة أظهرت اتجاه عكسي للنتائج المتحصل عليها لعناصر المحصول ومحصول الثمار. أيضاً أوضحت النتائج المتحصل عليها عند نظام الري لطول النبات، الوزن الطازج، الوزن الجاف، الجهد المائي للورقة ومحصول الثمار لنباتات الطماطم عند الحصاد والتي تعرضت للإجهاد الملحي وعند مستويات الري تحت الدراسة خلال مراحل النمو المختلفة عامة كانت أعلى من النتائج المتحصل عند الري السطحي المعدل ذو الفتحات. تحت نظام الري بالتنقيط، كانت النسب المئوية لنقص محصول الثمار مقارنة بمعاملة المقارنة 9,9 ، 16,0 و22,5 % وذلك للنباتات التي تعرضت للإجهاد الملحي باستخدام مياه ذو ملوحة 9,15 ديسيمنز/م عند مستويات الري100، 75 و50 % من البخر – نتح خلال مرحلة النمو وكانت 21,5، 28,8و41,5 % عند تعرضها خلال مرحلة التزهير وكانت النسب 11,6، 16,2و23,2 % عند تعرضها خلال مرحلة الحصاد على التوالي. بينما تحت نظام الري ذو الفتحات كانت النسب لنقص محصول الثمار 11,6 ، 13,7 و16,8 % وذلك للنباتات التي تعرضت للإجهاد الملحي باستخدام مياه ذو ملوحة 9,15 ديسيمنز/م عند مستويات الري 100، 75 و50 % من البخر – نتح خلال مرحلة النمو وكانت 20,6 ، 22,2 و29,1 % عند تعرضها خلال مرحلة التزهير وكانت النسب 13,2 ، 14,2 و17,7 % عند تعرضها خلال مرحلة الحصاد على التوالي. لذا كانت مرحلة النمو لنباتات الطماطم أقل مراحل النمو تأثراً للإجهاد الملحي باستخدام مياه ملحية ذو 9,15 ديسيمنز/م وإضافة مياه ري 100، 75 و 50 % من البخر – نتح، بينما كانت مرحلة التزهير أكثر المراحل تأثرا للإجهاد الملحي ونقص كميات مياه الري وخاصة عند 50 % من البخر – نتح وذلك لنظم الري تحت الدراسة.

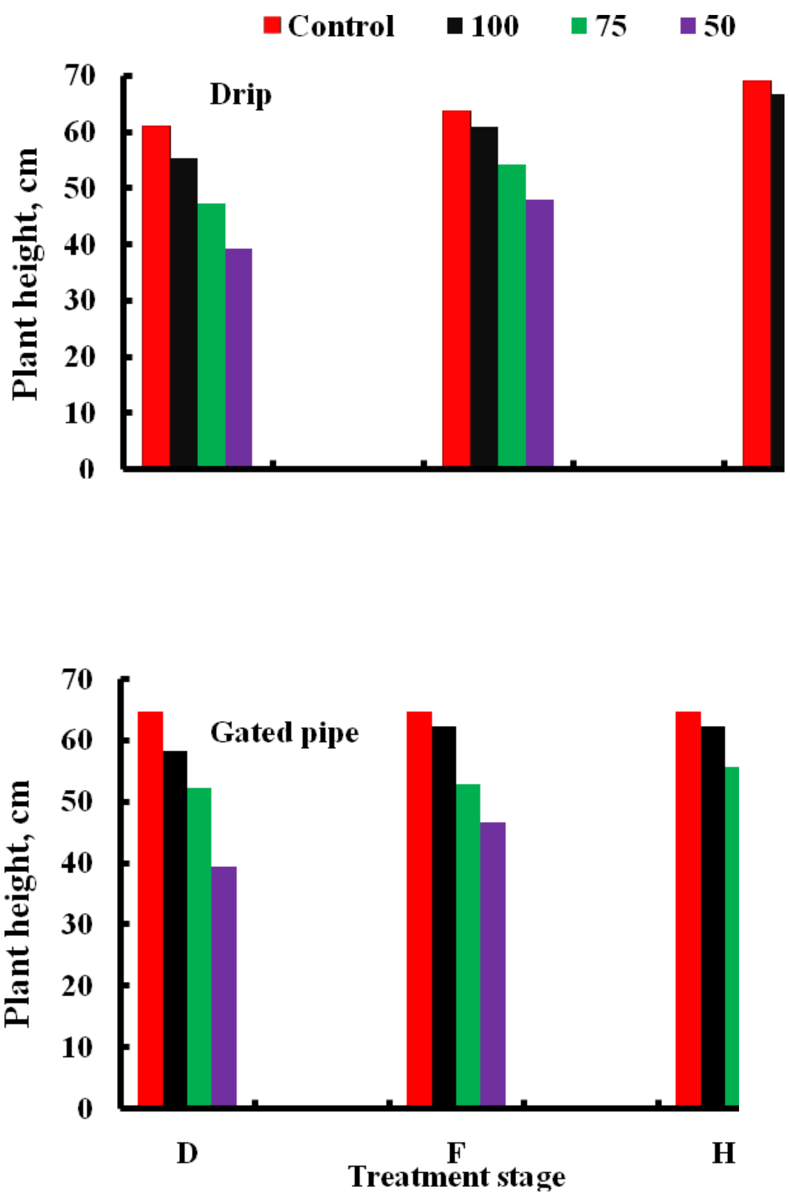


**Fig. (1): Plant height at the harvesting growth stage subjected to salt stress of 9.15 dSm$^{-1}$at irrigation water levels % ETc during different growth stages under studied irrigation systems.**

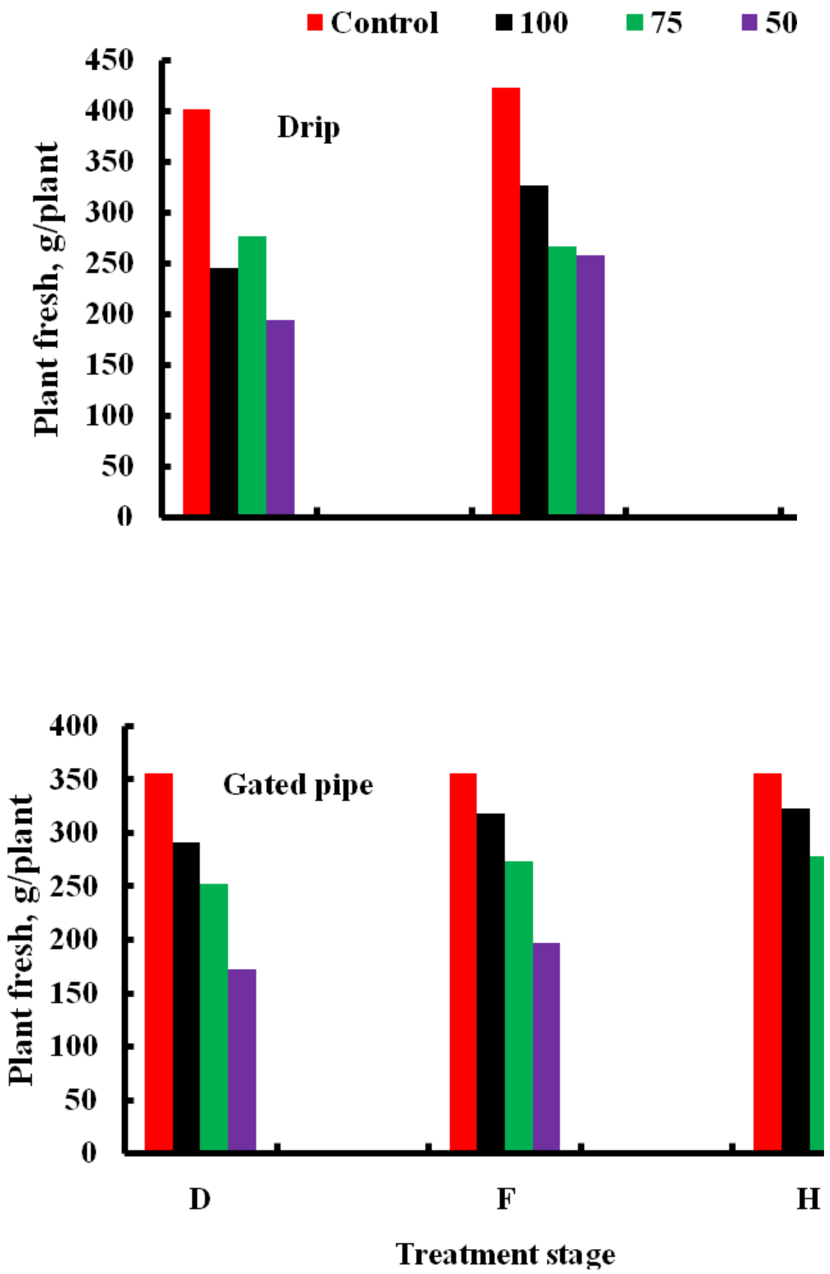


**Fig. (2): Plant fresh weight at the harvesting growth stage subjected to salt stress of 9.15dSm$^{-1}$at irrigation water levels % ETc during different growth stages under studied irrigation systems.**

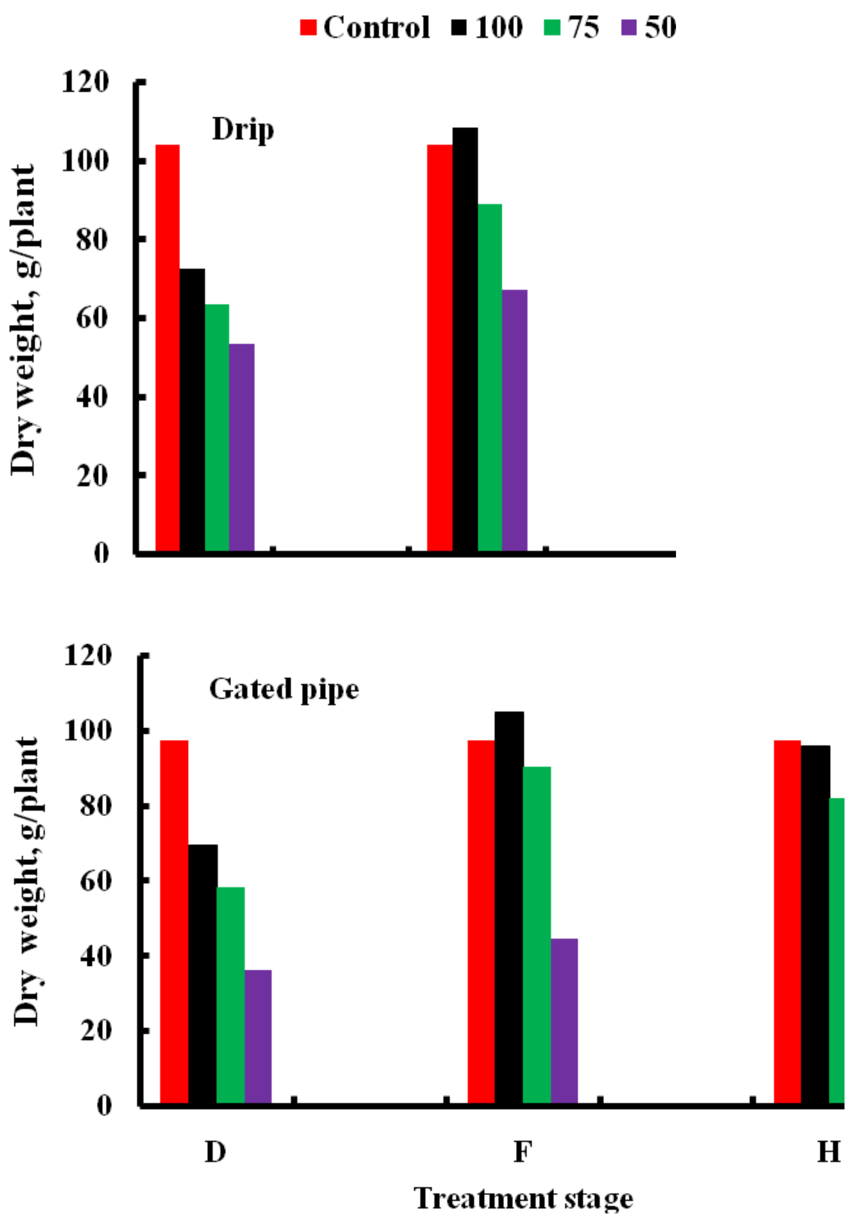


**Fig. (3): Plant dry weight at the harvesting growth stage subjected to salt stress of 9.15dSm$^{-1}$at irrigation water levels % ETc during different growth stages under studied irrigation systems.**

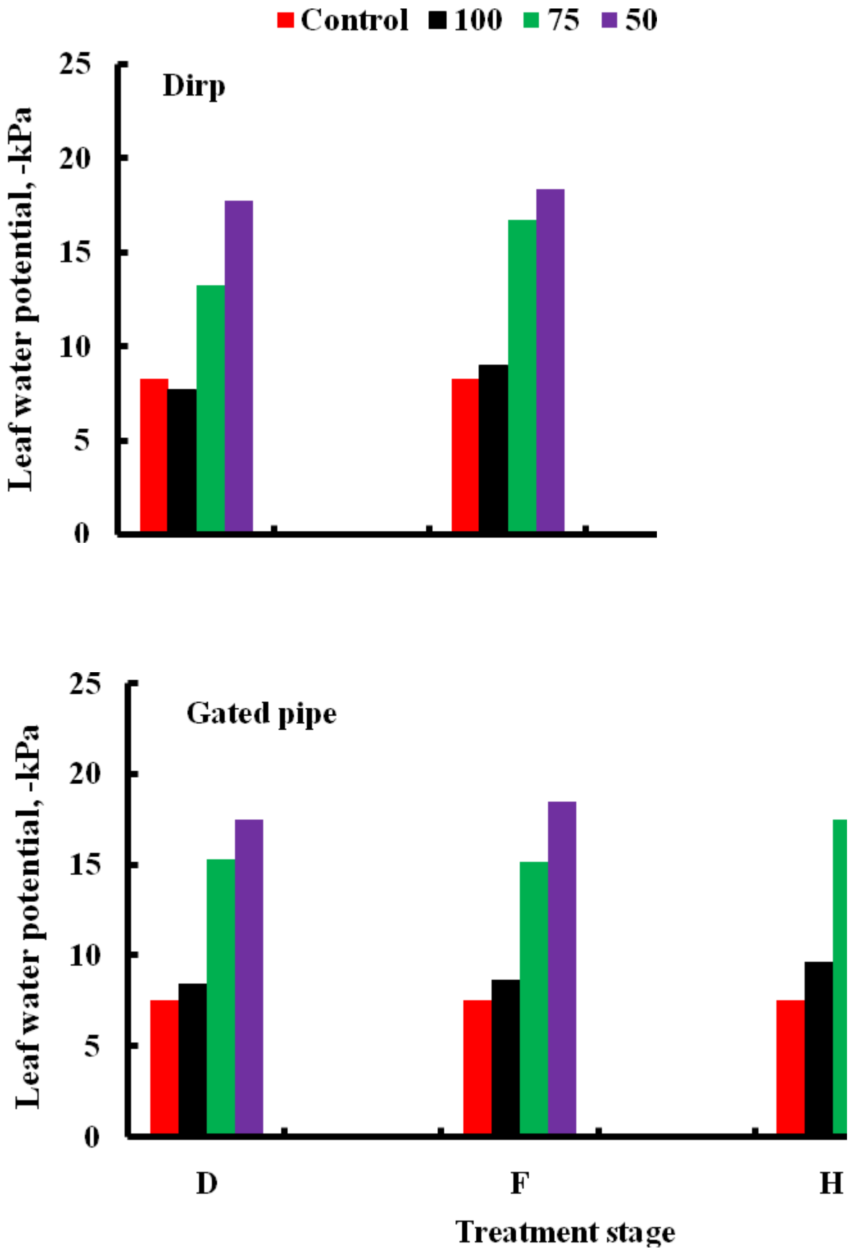


**Fig. (4): Plant leaf water potential at the harvesting growth stage subjected to salt stress of 9.15 $dSm^{-1}$ at irrigation water levels % ETc during different growth stages under studied irrigation systems.**

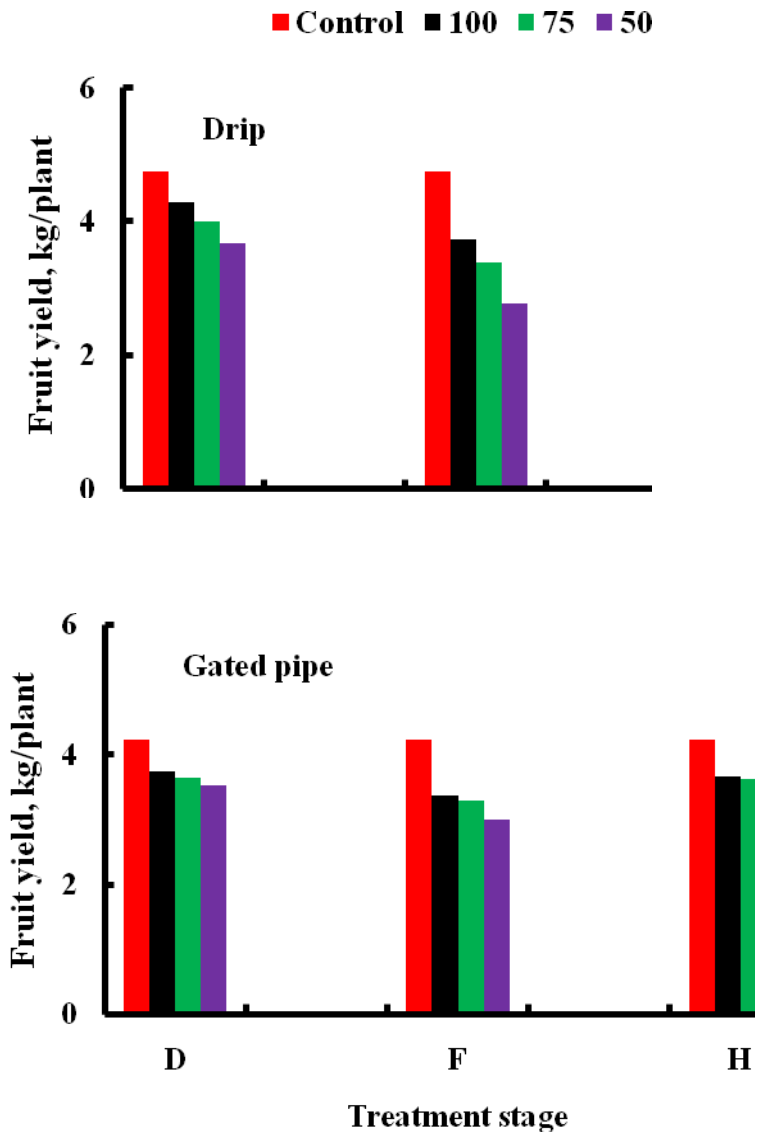


**Fig. (5): Tomato fruit yield at the harvesting growth stage subjected to salt stress of 9.15 $dSm^{-1}$ at irrigation water levels % ETc during different growth stages under studied irrigation systems.**