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**Research Article**

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# Effects of Drip Irrigation Applications in Eggplant on Salt Distribution in Soil

**Seda Devrim YENIGUN[1], Tolga ERDEM[2]***

[1]Nezahat Gokyigit Botanic Garden, Istanbul- Turkey
[2]Corresponding author, Tekirdag Agricultural Faculty, Dep. of Biosystem Engineering, Tekirdag-Turkey
terdem@nku.edu.tr

**Abstract** The study on the effects of different irrigation practices under drip irrigation method on eggplant water use and salt distribution was carried out under Tekirdag, Turkey conditions in 2015 and 2016. Four different irrigation water amounts with 5 days interval applied based on a ratio of Class A pan evaporation as 50, 75, 100 and 125 % were created in the research. In the first year of the study all treatments with irrigation water application 20 times between 283.0 and 693.0 mm with irrigation application, 19 times of 293.0 and 693.0 mm of irrigation water in the second year and was applied. As a result of this study, the seasonal evapotranspiration in the treatments during the measurement period varied from 466.2 and 837.0 mm in 2015 and from 411.7 and 797.1 mm in 2016 depend on irrigation water applied. It was observed that the salinity amount in all treatments increased in the profile (C) where the dripper was located and, in the profile, (A) located in the middle of the two laterals, together with the irrigation applications in the first year of the treatment. In the second year of the research, as the amount of increase in soil salinity moved away from the dripper and it was observed that the profiles between the two laterals (A) and between the two drippers (E) increased.

**Keywords** Evapotranspiration, salt, irrigation method, dripper

## 1. Introduction

The increase in water use brings along very important problems. For example, groundwater resources are running out, other water ecosystems are polluted and degraded. In addition, many environmental problems arise in irrigated agriculture. Considered as a renewable natural resource, water can cause problems such as losing this feature in limited areas. One of the most important environmental problems that arise in in-field irrigation practices is the accumulation of salt in soils in case of excessive irrigation under inappropriate irrigation management and in a poor drainage environment [1]. According to the estimates of FAO, about half of the irrigated areas are under the threat of salinity, alkalinity and ponding on the surface, which are the "silent enemy".

Irrigation method, which is defined as the way water is delivered to the root zone, affects the salinization profile in the soil. In conditions where water with high salinity and / or sodium content is used as irrigation water, the aim is to prevent decreases in plant yield, so it is necessary to be careful in terms of the irrigation method to be applied. Irrigation applications with low quality water require different applications than normal conditions. The salts contained in the irrigation water affect the plant depending on the irrigation method to be selected. The irrigation method should be chosen considering both the soil properties and the properties of the method. For example, if the soil texture is light (coarse), water with high salinity will be used more reliably since the irrigation interval will be shortened. In heavy textured soils, the irrigation interval may increase as the permeability will be low and some limitations may be encountered in the selection of the irrigation method. In this context, it is necessary to choose an irrigation method that will use the existing water in accordance with the climate, soil, topography and plant characteristics of the region effectively and that will not cause a decrease in productivity. Among the irrigation methods, the drip irrigation method comes to the fore especially in irrigation of vegetables, fruit trees and ornamental plants in terms of uniform water use, high efficiency, irrigation water saving and ease of operation [2].

Agricultural lands with vegetable production throughout the world increased by approximately 41% in the period 1995-2004 and reached approximately 51.5 million hectares. While Asia takes the first place in the world vegetable production area with 72%, this continent is followed by Africa with 10% and Europe with 9%. Countries with the most vegetable production in the world; China (43%), India (14%), Nigeria (3%), U.S.A. (3%) and Turkey (2%). In addition, the vegetables with the highest production area in the world are tomatoes (9%), watermelon (7%), cabbage (6%), cucumber (5%) and eggplant (3%) [3].

For this reason, this study which has been carried out in the form of field studies for two years, aims to solve an important problem in our country and region conditions. The values obtained as a result of the research will be used to determine the effects of drip irrigation, which has been increasingly used in regional conditions in recent years, on the salt distribution in the soil.

## 2. Materials and Methods

The research was conducted in 2015 and 2016 growing seasonsat Tekirdağ Viticulture Research Institute, Tekirdag, Turkey. The altitude of the study area is 4 m on average, the latitude is 40° 59′ north and longitude 27°29′ east. The research area is located in a semi-arid climate zone. According to long years averages, the annual average temperature is 13.9°C′.In terms of monthly average temperatures, the coldest month is January with 4.7 ºC and the hottest month is July with 23.8 C. Although the annual average rainfall is 580.8 mm, most of it occurs between October and April. Annual average relative humidity is 76.9% and the annual average wind speed value at 2 m height is 2.90 m $s^{-1}$ [4].

Soil type in the plot area was clay-loam. The bulk density ranged from 1.49 g $cm^{-3}$ to 1.61 g $cm^{-3}$. The available water in the upper 90 cm of the soil profile was 284.39 mm. Irrigation water quality is classified as $C_2S_1$ according to U.S. Salinity Lab.

A randomized plot design with three replications was used and the irrigation treatments consisted of four levels of cumulative pan evaporation (Ep) and water quantities applied were as 1.25 ($I_1$), 1.00 ($I_2$), 0.75 ($I_3$) and 0.50 ($I_4$) times of pan evaporation measured at five days interval by Class A Pan located in the experimental site. The amount of irrigation water was calculated by using the equation given below:

$$I = E_p \times k_{pc} \times P \quad (1)$$

Where I is the irrigation amount, $E_p$ is the cumulative pan evaporation for the5-day irrigation interval (mm), $k_{pc}$ is the coefficient of pan evaporation and P is the percentage of wetted area (P=75%).

Soil water content in the plots was gravimetrically measured every week in the 30 cm depth increments to 0.90 m, using by the hand sampler.

Evapotranspiration was estimated using the soil water balance equation [5]. The equation can be written as:

$$ET = I + P \pm \Delta SW - DP - RO \quad (2)$$

where ET is the evapotranspiration (mm), I is the irrigation water applied (mm), P is the precipitation (mm), ΔSW is the change in the soil water storage in the 0.60 m soil profile (mm), DP is the deep percolation (mm) and RO is the amount of runoff (mm). Since the amount of irrigation water was controlled, run off was assumed to be zero. The 0.90 m soil depth was measured for determination of deep percolation while irrigation was applied to 0.90 m soil depth.

The treatment area was 17.40 × 11.20 m and total 194.88 $m^2$. There are 12 parcels in total, 4 in each of the 3 blocks created. One plot has a total area of 6.72 $m^2$ with 2.4 × 2.8 m in size. There are 4 rows of plants in a plot. Eggplant were planted in experimental plots on May 27 in 2015 and on May 20 in 2016, with a row spacing of 0.60 m x 0.40 m. Irrigation water application was carried out by drip irrigation method. Lateral pipelines made of soft PE pipes with an outer diameter of 16 mm were laid in each plant row within the plots. Dripper flow rate has been selected as 4 $Lh^{-1}$ considering the structure of the soil and the infiltration rate according to the principles stated in [2]. The dripper interval is calculated as 45 cm taking into account the infiltration rate of the soil and the dripper flow rate.

Soil samples were taken as shown in Figure 1 in order to determine the salt distribution in the soil before and after irrigation water applications. As can be seen from the figure, the changes in the amount of salt in the soil were examined at a total of 15 points from five different points at three different depths. In both years, changes in the amount of salt in the soil were measured 4 times at the beginning of the irrigation season, 2 in the irrigation season and at the end of the irrigation season. Soil samples taken from the points indicated in 1 were sieved through a 2 mm sieve after drying. Electrical conductivity values were measured with a conductivimeter in soil suspensions diluted with 1/2.5 ratio of pure water [6, 7].

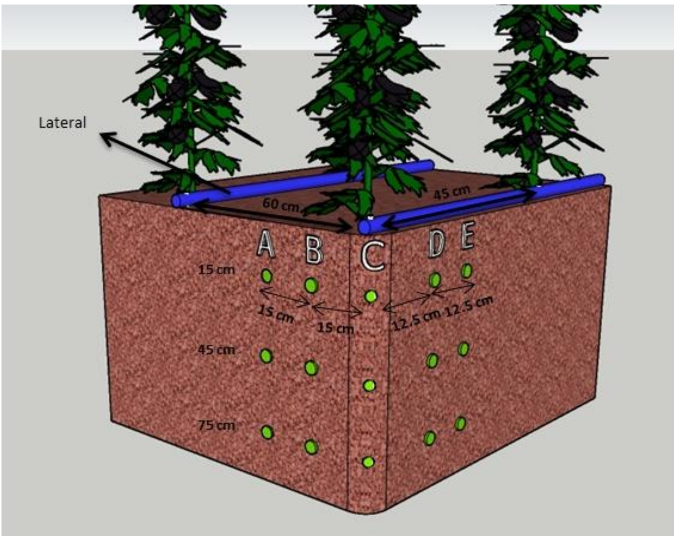


*Figure 1: Sampling points used to determine the amount of salt in the soil*

### 3. Results and Discussion

Table 1 shows data on applied irrigation water amounts, precipitation, measured soil water depletion and measured seasonal evapotranspiration for treatments under2015 and 2016 years. The seasonal evapotranspiration values measured from treatments during the growing season varied between 466.2 mm and 837.0 mm for 2015 and between 411.7 mm and 797.1 mm for 2016. The total seasonal measured evapotranspiration values for the eggplant are similar to previous studies conducted in Turkey and in the world [8, 9]. As the amount of irrigation water applied increased, measured season evapotranspiration values increased. The daily evapotranspiration values were 2.1 to 9.5 mmday$^{-1}$ for $I_1$ treatment, 1.6 to 8.2 mm day$^{-1}$ for treatment, 1.7 to 6.4 mmday$^{-1}$ for $I_3$ treatment and 2.6 to 5.5 mmday$^{-1}$ for $I_4$ treatment. In the second year of the research, the daily evapotranspiration values were 4.6 to 9.7 mmday$^{-1}$ for $I_1$ treatment, 4.3 to 8.2 mmday$^{-1}$ for $I_2$treatment, 3.7 to 6.5 mmday$^{-1}$ for $I_3$ treatment and 3.0 and 5.2 mmday$^{-1}$ for $I_4$ treatment. The daily evapotranspiration values increased according to the amount of irrigation water applied and decreased depending on the deficit irrigation, daily temperature and sunshine duration.

**Table 1:** Applied irrigation water and measured seasonal evapotranspiration for treatments

| Year | Treatments | Soil water depletion (mm) | Rainfall (mm) | Applied irrigation water (mm) | Seasonal evapotranspiration (mm) |
|---|---|---|---|---|---|
| | $I_1$ | 44.2 | 99.8 | 693.0 | 837.0 |
| 2015 | $I_2$ | 53.9 | | 556.0 | 709.7 |
| | $I_3$ | 63.4 | | 420.0 | 583.2 |
| | $I_4$ | 83.4 | | 283.0 | 466.2 |
| | $I_1$ | 38.4 | 47.2 | 711.5 | 797.1 |
| 2016 | $I_2$ | 52.5 | | 571.0 | 670.7 |
| | $I_3$ | 78.2 | | 432.8 | 538.2 |
| | $I_4$ | 71.5 | | 293.0 | 411.7 |

In the first year of the research, soil salt changes were measured 4 times in total, on May 20 before the irrigation season, on July 29 and August 27 in the middle of the irrigation season, and on September 20 at the end of the irrigation season. The values obtained ranged from 157 to 281 µmhos $cm^{-1}$ for the $I_1$ treatment, 157 to 284 µmhos $cm^{-1}$ for the $I_2$ treatment, 157 to 494 µmhos $cm^{-1}$ for the $I_3$ treatment and 157 to 382 µmhos $cm^{-1}$ for the $I_4$ treatment. When all treatments were examined, it was seen that the salt values in the soil before the irrigation season changed between 157 and 227 µmhos $cm^{-1}$on average and decreased as the soil depth increased. As a result of the measurements made on July 29, which coincides in the middle of the irrigation season, the amount of salt in the soil decreased in the first 15 cm layer compared to the values obtained before the irrigation season except for the $I_3$ treatment, and started to increase in the 45 and 75 cm layers. In the measurements made on August 27, which is another measurement date, it was seen that the amount of salt in the soil decreased according to the measurements taken on July 29, except for the $I_2$treatment.As a result of the samples taken on September 20 after the irrigation season was completed, it was determined that there was an increase in the average salt amount in all treatments.

Different results were obtained when the distribution of soil salt distribution amounts along profiles were examined. In the C profile, it was determined that the amount of salt in the soil increased in each layer and in each treatment with irrigation applications and when the values obtained were examined between the depths, it was seen that the amount of soil salt was generally higher near the surface. In the A, B and D profiles, it was determined that the amount of salt in the soil decreased in each layer with irrigation applications and in other irrigation issues except $I_1$treatment and when the values obtained were examined between the depths, it was seen that the amount of soil salt was generally higher at 45 cm depth. In the E profile, it was determined that the amount of salt in the soil decreased in each treatment with irrigation applications and in other irrigation issues except $I_1$ treatment and it was seen that the amount of soil salt was generally higher at 15 cm depth.

The second year of the research in 2016, soil salt changes were measured 4 times in total, on May 20 before the irrigation season, on July 25 and August 20 in the middle of the irrigation season, and on September 25 at the end of the irrigation season. The values obtained ranged from 242 to 394 µmhos $cm^{-1}$for the $I_1$ treatment, 233 to 358 µmhos $cm^{-1}$ for the $I_2$ treatment, 231 to 402 µmhos $cm^{-1}$ for the $I_3$ treatment, and 249 to 402 µmhos $cm^{-1}$ for the $I_4$ treatment. When all treatments were examined, it was seen that the salt values in the soil before the irrigation season changed between 364 and 402 µmhos $cm^{-1}$on average and decreased as the soil depth increased. As a result of the measurements made on July 25, which coincides in the middle of the irrigation season, the amount of salt in the soil started to decrease in all layers compared to the values obtained before the irrigation season. In the measurements made on August 20, which is another measurement date, it was observed that the amount of salt in the soil increased according to the measurements taken on July 25. As a result of the samples taken on September 25, after the irrigation season was completed, it was determined that there was an increase in the average salt amount in all treatments.

In the second year of the experiment, different results were obtained when the distribution of soil salt distribution amounts along the profiles were examined. In the C profile, it was determined that the amount of salt in the soil decreased in each layer and in each treatment together with irrigation applications. When the values obtained were examined between depths, it was seen that the amount of soil salt was generally higher near the surface. In addition, it can be said that the amount of irrigation water applied did not create significant differences in the measured salt amounts between treatments. In the A, B, D and E profiles, it was determined that the amount of salt in the soil decreased in each layer and in each treatment with irrigation applications and it was seen that the amount of soil salt was generally higher at 15 cm depth.

The change values calculated according to the amount of salt measured at the beginning and end of the irrigation season for each trial are given in Table 2 and Table 3.In the first year of the research, along with the irrigation applications, it was observed that the salinity in all trial subjects generally increased in the profile (C) where the dripper was located and, in the profile, (A) in the middle of the two laterals. It was determined that soil salinity increased in all profiles at the end of the irrigation season especially in the $I_4$ treatment. In the second year of the treatment, as the amount of increase in soil salinity moved away from the dripper and it was observed that the profiles between the two laterals (A) and between the two drippers (E) increased. The values obtained in the second year are especially in line with the results of previous studies regarding the salt distribution in the soil as a result of irrigation applications in the drip irrigation method [7, 10-14].

**Table 2:** Changes in soil salt content among treatments (2015)

| Treatment | Depth | Profile (µmhos/cm) | | | | |
|---|---|---|---|---|---|---|
| | (cm) | A | B | C | D | E |
| $I_1$ | 15 | 114 | 35 | 211 | 38 | -68 |
| | 45 | 70 | -97 | 6 | -2 | -59 |
| | 75 | 116 | -55 | 22 | 78 | 24 |
| $I_2$ | 15 | 258 | 33 | 63 | 64 | 104 |
| | 45 | 89 | 21 | -6 | 10 | 66 |
| | 75 | 29 | 13 | 54 | -8 | 25 |
| $I_3$ | 15 | -185 | -67 | 154 | 112 | 39 |
| | 45 | 132 | -40 | 125 | 52 | -39 |
| | 75 | -77 | -105 | -108 | -83 | -67 |
| $I_4$ | 15 | 140 | 113 | 214 | 111 | 201 |
| | 45 | 124 | 103 | 247 | 166 | 161 |
| | 75 | 67 | 98 | 186 | 81 | 67 |

**Table 3:** Changes in soil salt content among treatments (2016)

| Treatment | Depth | Profile (µmhos/cm) | | | | |
|---|---|---|---|---|---|---|
| | (cm) | A | B | C | A | E |
| $I_1$ | 15 | 148 | 41 | 39 | 50 | 91 |
| | 45 | 48 | 67 | 61 | 42 | 89 |
| | 75 | 36 | 88 | 114 | 59 | 48 |
| $I_2$ | 15 | 20 | 41 | 83 | 10 | 158 |
| | 45 | 35 | 16 | 83 | -22 | 52 |
| | 75 | 55 | 28 | 276 | 93 | 26 |
| $I_3$ | 15 | 318 | 63 | -2 | 163 | 54 |
| | 45 | 27 | 41 | 17 | 48 | 39 |
| | 75 | 88 | 21 | 9 | 77 | 74 |
| $I_4$ | 15 | -217 | -1 | 44 | -81 | 203 |
| | 45 | -153 | -127 | -24 | -169 | -4 |
| | 75 | -19 | -131 | -101 | -58 | -39 |

## Conclusion

In the study, together with irrigation practices, measurements for the change of soil salinity were carried out at 4 different times in both years, before the irrigation season, 2 during the irrigation season and at the end of the irrigation season. It was observed that the salinity amount in all treatments increased in the profile (C) where the dripper was located and, in the profile, (A) located in the middle of the two laterals, together with the irrigation applications in the first year of the treatment. It was determined that soil salinity increased in all profiles at the end of the irrigation season, especially in the I4 treatment. In the second year of the research, as the amount of increase in soil salinity moved away from the dripper and it was observed that the profiles between the two laterals (A) and between the two drippers (E) increased. The values obtained in the second year are especially in line with the results of the previous studies regarding the salt distribution in the soil as a result of irrigation applications in the drip irrigation method.

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