Effect of Irrigation Systems and Water Regime on Growth, Yield Components, Water Use Efficiency and Water Productivity of Guava (PSIDIUM GUAVAJA L.) Grown in Clay Soil

Ashraf E. Elnamas

ABSTRACT

Field experiments were conducted during two successive growing seasons (2017/2018 and 2018/2019) in Guava orchard at Kafr Al Dawar district, Beheira Governorate, Egypt, to investigate the effect of water regime levels: 100% (E1), 80% (E2) and 60% (E3) of crop evapotranspiration (ETo) under two irrigation systems: furrow irrigation (I1) and surface drip irrigation (I2) on water use efficiency, growth parameters, yield components, and economic analysis of four years old guava trees grown in clay soil. The field experiments were implemented in a randomized complete block design with three replicates. The obtained results indicated that the highest shoot length, number of leaves/m and leaf area were obtained due to T1E1 treatment (drip irrigation with 100% ETo), followed by I1E2 treatment (drip irrigation with 80% ETo). The average highest guava yield of the two growing seasons was 26.64 tons/ha which was obtained as a result of I2E2 treatment (drip irrigation with 100% of ETo). The lowest guava yield (20.24 and 17.90 tons/ha) were obtained due to I1E3 treatment (furrow irrigation with 60% of ETo) for the two growing seasons, respectively. Yield components such as number of fruits/m, length of fruit (cm), diameter of fruit (cm), fruit size (cm3), fruit weight (gm) and yield (kg/tree) were significantly effected (P<0.05) by water regime levels and irrigation systems. Water use efficiency (WUE) of drip-irrigated treatments was higher than that obtained from furrow irrigated treatments in the two growing seasons. WUE increased from 2.37 to 3.34 kg.m-3 for drip - irrigated treatment, and from 1.63 to 2.18 kg.m-3 for furrow - irrigated treatments. Fruit quality such as TSS (%), acidity (%) and TSS / Acidity ratio were not significantly affected by irrigation systems and water regime. For the economical results, the maximum value of net return was due to I2E3 (24411 LE/fed) treatment for the two growing seasons and the minimum value of total return was the result of T1E3 (6344 LE/fed) treatment for the two growing seasons. The maximum values of water productivity were obtained under T2E1 (5.56 LE/m3) and I2E2 (5.25 LE/m3) treatments in the two growing seasons.

Key Words: Guava, Clay soil, Drip irrigation, Furrow irrigation, Yield component, Water use efficiency, Water productivity.

INTRODUCTION

Guava (PSIDIUM GUAVAJA L.) is one of the major fruits in Egypt and is ranked the eighth most important fruit as per area and production. The fruit is a rich source of vitamin C, pectin and minerals like calcium, phosphorus and iron. The total area planted with guava is about 16,531 hectares. This area is divided into 12,838 hectares in old areas that are irrigated by surface irrigation methods, while 3,692 hectares in new lands that are irrigated by modern irrigation methods.

Egypt is seeking to increase the new reclaimed lands, but limited water resources constrain ambitious expansion plans (Abdel Mowgowd et al., 2010 and Darwish et al., 2013). Therefore, Egypt initiated a strategic program aiming to reclaim 1.4 million hectares of desert during the coming years till 2020 (Abdel - Mowgowd et al., 2010). Climate change has forced decision makers and scientists to think about the future of water resources (Bisbis et al., 2018 ) and their sustainability in a scarcity situation, taking into account less water coming from Ethiopia to Egypt and a high rate of population growth (Ouda, 2016). So that, Badr et al., (2010) and Saleh et al., (2012) recommend the use of modern irrigation systems, instead of traditional surface irrigation such as furrow irrigation. Efficient water delivery systems can contribute towards increased crop yield and improving crop water use efficiency (Badr et al., 2010). Improving WUE may help to minimize water consumption, reduce losses of irrigation water, and increase cultivated area.

Currently in Egypt, the country’s tendency to convert surface irrigation systems into modern irrigation systems due to a 30% decrease in the efficiency of surface irrigation on modern irrigation methods due to the loss of seepage and evaporation, as well as increasing the amount of water added during irrigation and deep percolation (Singh, 2005).

Drip irrigation has arguably become the world's most valued innovation in agriculture irrigation since the invention of the impact sprinkler, which replaced flood irrigation. It proves efficiently in providing irrigation water and nutrients to the roots of plants, while maintaining high yield production. Furrow irrigation is the conventional method widely used to irrigate most of the fruit crops grown in old areas, Egypt. However, this method uses more water.

DOI: 10.21608/ASEJAIQJSAE.2020.101396

1 Department of Soil and Water Science, Faculty of Agric., Alexandria University
Received May 20, 2020, Accepted, June 29, 2020.
compared to other high-tech water-saving irrigation methods such as sprinkler, drip etc. Many researchers have reported higher application efficiency of drip irrigation systems over the conventional basin irrigation systems (Salvin et al., 2000; Bharambe et al., 2001; Agrawal and Agrawal, 2007) as compared to drip and furrow irrigation systems in fruits since they found that there was savings of 40 to 60% more irrigation water than another surface irrigation methods.

Guava is often marketed as "super-fruit" which has a considerable nutritional importance in terms of vitamins A and C with seeds that are rich in omega-3, omega-6 polyunsaturated fatty acids and especially dietary fiber, riboflavin, as well as proteins, and mineral salts. The high content of vitamin C (ascorbic acid) in guava makes it a powerhouse in combating free radicals and oxidation that are key enemies that cause many degenerative diseases. The high content of vitamin A in guava plays an important role in maintaining the quality and health of eyesight, skin, teeth, bones and the mucus membranes (Singh and Singh, 2007). Patil and Patil (1999) revealed that guava fruit yield was high at maximum when irrigated at 80% of the potential evapotranspiration. Singh and Singh (2007) observed that there was 164% greater yield in case of drip as compared to furrow irrigation in guava.

The aim of this research was to evaluate the effect of deficit irrigation treatments and irrigation systems on the vegetative growth, yield and yield components, applied irrigation water, water use efficiency and economic return analysis of guava plants grown in clay soil.

**MATERIALS AND METHODS**

Field experiments were carried out in a private orchard at Kafr Al Dawwar district, Beheira Governorate, Egypt (31° 13’ N, 30° 25’ E) during two growing successive seasons: 2017 / 2018 and 2018 / 2019 to study the effects of irrigation systems and water regime on the growth performance of guava (Psidium Guajava L.) grown in clay soil. The meteorological data of the experimental site are given in Table 1.

**Table 1. The meteorological data of the experimental site during the two growing seasons 2017 /2018 and 2018 /2019**

| Months | Temperature (°C) | Relative Humidity(%) | Precipitation (mm) | Wind speed(m/hr) | Sun shine (hr.) |
|--------|-----------------|----------------------|---------------------|------------------|----------------|
|        | Maximum | Minimum | Mean  | Maximum | Minimum | Mean  | Maximum | Minimum | Mean  | Maximum | Minimum | Mean  | Maximum | Minimum | Mean  |
| 2017 / 2018 | | | | | | | | | | | | | | | |
| Jan.  | 18.2   | 12.6    | 15.4  | 69.1   | 33.9    | 5.4   | 9.3    | | | | | | | | |
| Feb.  | 20.1   | 12.8    | 16.5  | 69.1   | 12.1    | 4.3   | 10.5   | | | | | | | | |
| Mar.  | 23.7   | 14.2    | 19.0  | 59.6   | 1.5     | 5.2   | 11.3   | | | | | | | | |
| Apr.  | 25.6   | 16.2    | 20.9  | 59.7   | 2.8     | 4.5   | 12.1   | | | | | | | | |
| May   | 28.9   | 20.0    | 24.5  | 60.9   | 0.0     | 4.4   | 12.8   | | | | | | | | |
| June  | 31.0   | 22.5    | 26.3  | 58.2   | 0.0     | 4.3   | 13.2   | | | | | | | | |
| July  | 32.2   | 24.2    | 28.2  | 63.5   | 1.7     | 4.7   | 13.3   | | | | | | | | |
| Aug.  | 32.1   | 25.0    | 28.6  | 64.5   | 0.0     | 4.5   | 12.8   | | | | | | | | |
| Sep.  | 31.2   | 24.0    | 27.6  | 63.6   | 0.0     | 4.8   | 12.1   | | | | | | | | |
| Oct.  | 28.1   | 21.7    | 24.9  | 63.6   | 11.1    | 4.6   | 10.9   | | | | | | | | |
| Nov.  | 24.2   | 18.3    | 21.3  | 64.4   | 23.4    | 4.1   | 9.7    | | | | | | | | |
| Dec.  | 19.5   | 14.8    | 17.2  | 68.5   | 51.0    | 5.3   | 9.2    | | | | | | | | |
| 2018 / 2019 | | | | | | | | | | | | | | | |
| Jan.  | 17.3   | 10.4    | 13.9  | 64.1   | 25.2    | 5.9   | 9.6    | | | | | | | | |
| Feb.  | 18.3   | 11.1    | 14.7  | 67.2   | 14.3    | 4.9   | 10.4   | | | | | | | | |
| Mar.  | 19.8   | 12.5    | 16.2  | 66.5   | 25.3    | 5.1   | 11.1   | | | | | | | | |
| Apr.  | 22.8   | 14.2    | 18.5  | 62.0   | 3.5     | 4.8   | 12.2   | | | | | | | | |
| May   | 29.1   | 18.4    | 23.8  | 53.9   | 0.0     | 4.6   | 12.6   | | | | | | | | |
| June  | 30.9   | 22.8    | 26.9  | 63.1   | 0.0     | 4.6   | 13.4   | | | | | | | | |
| July  | 32.4   | 24.5    | 28.5  | 61.1   | 0.0     | 4.7   | 13.5   | | | | | | | | |
| Aug.  | 32.7   | 24.6    | 28.7  | 63.3   | 0.0     | 4.4   | 13.0   | | | | | | | | |
| Sep.  | 30.4   | 23.4    | 26.9  | 63.7   | 0.0     | 4.6   | 12.2   | | | | | | | | |
| Oct.  | 28.8   | 21.9    | 25.4  | 65.8   | 17.9    | 4.4   | 10.7   | | | | | | | | |
| Nov.  | 26.3   | 18.9    | 22.6  | 63.1   | 0.2     | 4.3   | 9.5    | | | | | | | | |
| Dec.  | 20.4   | 14.9    | 17.8  | 67.7   | 40.2    | 5.6   | 9.3    | | | | | | | | |

*From the following website: https://power.larc.nasa.gov/data-access-viewer.*
Four years old guava trees were grown at 4.0 x 4.0 m. apart in clay soil. The fertilizers dose of 100 % which included, 138 g N, 244 g P and 360 g K was applied to each tree of the recommended dose as suggested by Ministry of Agriculture and Land Reclamation (MALR) was followed.

Experimental Layout:

Two irrigation methods and irrigation water regime was applied during two successive growing seasons; 2017/2018 and 2018/2019. Two irrigation methods were furrow irrigation (FI) and surface drip irrigation (SDI) and three irrigation water regime (100, 80 and 60 % of crop evapotranspiration (ETc) from class A pan evaporation (FAO, 1998).

The overall treatments were:

i. I1E1 Furrow irrigation + 100 % of ETc (Control)
ii. I1E2 Furrow irrigation + 80 % of ETc
iii. I1E3 Furrow irrigation + 60 % of ETc
iv. I2E1 Surface drip irrigation + 100 % of ETc
v. I2E2 Surface drip irrigation + 80 % of ETc
vi. I2E3 Surface drip irrigation + 60 % of ETc

The drip irrigation system, used in the orchard farm, included, an irrigation pump connected to sand and screen filters, and a hydraulic fertilizer injection pump. The main line is made of a PVC pipe of 63mm diameter. Laterals of 16 mm diameter are connected to sub main line. Each later is 50 m long with standard drippers of 4 l/h discharge rate, spaced at 0.5m apart. Two laterals served each row of guava trees.

Class A pan was used to determine the amount of applied irrigation water for the proposed irrigation treatments. Potential evapotranspiration (ETp) values were obtained from the class A pan method as follows:

\[ \text{ET}_p = \text{E}_{\text{pan}} \times K_{\text{pan}} \] (Doorenbos and Pruitt, 1984)

Where:

- \( \text{E}_{\text{pan}} \): is pan evaporation rate (mm/day)
- \( K_{\text{pan}} \): is pan coefficient. Its value depends on the relative humidity, wind speed and the site of the pan

The \( K_{\text{pan}} \) value of 0.75 was used at the experimental site according to the weather condition.

Soil water relations:

Soil moisture content was gravimetrically determined in soil samples taken from consecutive depth of 20 cm each till 100 cm depth. These samples were taken just before each irrigation, 24 hours after irrigation and at harvesting to determine water consumptive use. Field capacity, wilting points and available soil moisture were determined in the field (Michael, 1978). The bulk density was determined by using the core method (Vomocil, 1957) to a depth of 100 cm. The average values are presented in Table 2. Some chemical and physical properties of the used soil were determined according to Black (1965) and Page et al. (1982) and the results obtained are presented in Table 3.

| Soil depth (cm) | FC (%) | WP (%) | ASM (%) | Dₜb (g/cm³) |
|----------------|--------|--------|---------|-------------|
| 0-20           | 38.7   | 17.3   | 21.4    | 1.11        |
| 20-40          | 37.5   | 16.7   | 20.8    | 1.13        |
| 20-60          | 32.3   | 16.3   | 16.0    | 1.22        |
| 60-80          | 29.9   | 15.1   | 14.8    | 1.27        |
| 80-100         | 28.3   | 14.5   | 13.8    | 1.32        |
| Average        | 33.3   | 16.0   | 17.4    | 1.21        |

Table 2. The mean values of field capacity (FC), wilting points (WP), available soil moisture (ASM) and bulk density (Dₜb) of the soil of the experimental farm

| Soil depth (cm) | EC (dS/m) | pH | O.M. (%) | CaCO₃ (%) | Coarse Sand(%) | Fine Sand(%) | Silt (%) | Clay (%) | Texture |
|----------------|-----------|----|----------|-----------|---------------|-------------|----------|----------|---------|
| 0-20           | 1.08      | 8.01 | 1.12     | 2.03      | 4.9           | 8.5         | 31.2     | 55.4     | Clay    |
| 20-40          | 1.01      | 7.93 | 1.01     | 1.76      | 7.9           | 10.5        | 29.4     | 52.2     | Clay    |
| 20-60          | 0.89      | 8.03 | 0.74     | 1.70      | 10.6          | 14.1        | 29.0     | 46.3     | Clay    |
| 60-80          | 0.79      | 7.82 | 0.64     | 1.55      | 12.9          | 15.5        | 27.1     | 44.5     | Clay    |
| 80-100         | 0.67      | 7.84 | 0.34     | 1.04      | 11.3          | 22.7        | 26.5     | 39.5     | Clay loam |
| Average        | 0.89      | 7.93 | 0.77     | 1.62      | 9.5           | 14.3        | 28.6     | 47.6     | Clay    |
Water consumptive use (WCU):
Water consumptive use was calculated using the following equation (Israelsen and Hansen, 1962):

\[ Cu = \sum_{i=1}^{n} \left( \frac{\theta_2 - \theta_1}{100} \right) \times Db \times Di \]

Where:
- \( Cu \) = Water consumptive use (cm), in effective root zone (100 cm).
- \( Di \) = Soil layer depth (20 cm).
- \( Db \) = Soil bulk density (g/cm\(^3\)), of the specified soil layer.
- \( \theta_1 \) = Soil moisture % before irrigation.
- \( \theta_2 \) = Soil moisture %, 24 hours after irrigation.

Applied irrigation water (AIW):
The amount of water applied per each irrigation was measured by flow meter in furrow irrigation and calculated according to the following equation in drip irrigation:

\[ AIW = \frac{ET_0 \times K_c \times Kr \times Ea}{K_r} + LR \]

Where:
- \( AIW \) = Applied irrigation water depth (mm).
- \( ET_0 \) = Reference crop evapotranspiration (mm/day) values obtained by class A pan evaporation method.
- \( K_c \) = Crop coefficient.
- \( K_r \) = Reduction factor that depends on ground cover. It equals 0.7 for mature plants.
- \( Ea \) = Irrigation efficiency (%) = 0.85.
- \( LR \) = Leaching requirements = 10 % of the total amount of water applied.

Water use efficiency (WUE):
It was calculated according to the following equation (Vites, 1962 and Stanhill, 1986).

\[ WUE = \frac{Y_a}{AIW} \]

Where:
- \( WUE \) : water use efficiency (kg/m\(^3\)).
- \( Y_a \) : actual yield (kg/ fed.)
- \( AIW \) : applied irrigation water (m\(^3\)/fed)

Vegetative and flowering growth:
The shoot lengths (cm), number of leaves/ m and leaf area (cm\(^2\)) using planimeter were measured.

Fruit characteristics and yield:
Number of fruits/m, mean length and diameter of fruit (cm), mean fruit size (cm\(^3\)), mean fruit weight (g) and yield (kg/tree) were measured.

Fruit chemical properties:
These properties included:
1. Total soluble solids (TSS %) were determined by a‘bbe refractometer using the method of A.O.A.C. (1995).
2. Total acidity (%) was determined by titration method as described by A.O.A.C. (1975).
3. TSS/acidity was calculated as a ratio.
4. Vitamin C (ascorbic acid) was determined by the method described by Horwitz (1970) as mg/100 g fruit flesh.

Economic Analysis
The prices in-puts and out-puts were calculated for the different treatments for guava. Concerning costs of irrigation in the two seasons for different treatments was calculated on the basis of rent of water. According to the marketing and employment conditions of the private orchard at Kafr El Dawar district, Beheira Governorate.

Total production costs (LE/fed.) was calculated according to the following equation:

Total production costs (LE/fed.) = Irrigation system costs (fixed and running cost) + cost of cultivation (Preparation of soil, different agriculture practices, price of seed, labours and harvesting)

Total return (LE/fed): was calculated according to the following equation:

Total return = Price (LE/ton) × Fruit yield (ton/fed)

Net return: was calculated according to the following equation:

Net return = Total return - Total costs

Water productivity, (WP, LE/m\(^3\)): was calculated by using the following formula:

\[ \text{Water productivity} = \frac{\text{Net return} (\text{LE/fed.})}{\text{Amount of water applied} (\text{m}^3/\text{fed})} \times \text{LE/m}^3 \]

Statistical Analysis.
The obtained data were subjected to statistical analysis of the least significance difference (LSD) at 5% level of probability to compare treatment means when F-test was significant (SAS Institute, 1996).
RESULTS AND DISCUSSION

Vegetative growth parameters:

Table 4 indicated that irrigation systems and water regime significantly affected all vegetative growth parameters of guava plants during the two growing seasons. The highest significant values were obtained as a result of drip irrigation and 100% ETc treatment (I2E2c), followed by drip irrigation and 80% ETc treatment (T2E2c) with non-significant differences between them. However, the lowest values were obtained as result of furrow irrigation and 60% ETc (I1E3c) treatment.

The mean values of shoot length were 21.9, 21.2, 16.3, 23.6, 23.3, and 17.3 cm as result of the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c, respectively for the first growing season (2017/2018) and were 20.8, 20.4, 16.8, 23.3, 22.8, and 17.2 cm as result of the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c respectively for the second growing season (2018/2019).

The mean number of leaves/m were 84.3, 78.3, 65.2, 100.5, 93.4, and 72.3 due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c, respectively for the growing season 2017/2018 and were 91.8, 86.2, 62.3, 103.4, 97.6, and 76.8 due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c, respectively for the growing season 2018/2019.

The mean values of leaf area (cm²) were 49.10, 46.30, 36.20, 52.40, 50.30, and 41.60 cm² due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c, respectively for growing season 2017/2018 and were 46.3, 44.2, 34.4, 51.6, 49.3, and 37.2 cm² due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c, respectively for growing season 2018/2019.

These results are in harmony with those obtained by El-Dakrouy (2008), who showed that increasing irrigation level from 60% up to 100% ETc significantly increased the vegetative growth parameters of beans. This may be due to the role of water in increasing the uptake of nutrients from soil and translocation for photosynthetic assimilates. Thus, increasing in the leaf number and leaf area as well as foliage weight per plant (Leilah, 2009). Farooq et al. (2009) and Zhang and Huang (2013) reported that drought stress causes various physiologic and biochemical effects in plants. Mutava et al. (2015) found that the reduction in shoot fresh and dry biomass, shoot length, leaf area per soybean plant, transpiration rates, stomata conductance, photosynthetic rate, relative water content and leaf water potential were accompanied to drought water stress.

Yield and Yield components

Yield of Guava:

Table 5 showed that yield and yield components of guava were significantly affected (P<0.05) by irrigation systems and water regime. The yield of guava were 10.58, 9.96, 8.50, 11.33, 10.90 and 9.32 (ton fed⁻¹) due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c respectively for the growing season 2017/2018 and were 10.32, 9.53, 7.52, 11.05, 10.33 and 8.75 (ton fed⁻¹) due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c and I2E3c respectively for the growing season 2018/2019. The lowest guava yield was obtained as a result of T1E3c treatment (furrow irrigation and 60% of ETc), which recorded 8.50 and 7.52 ton fed⁻¹, respectively for the growing seasons 2017/2018 and 2018/2019. The highest guava yield was obtained as a result of T2E1c treatment (drip irrigation and 100% of ETc), which recorded 11.33 and 11.05 ton fed⁻¹, respectively for the growing season 2017/2018 and 2018/2019. These results are in harmony with those obtained by Biswas et al. (1999) and Patil and Patil (1999) who observed that at drip irrigation, the guava fruit yield was the highest when irrigated with 100 % of ETc.

Yield components:

The yield components were measured during each growth season for each treatment (Table 5). It is clear that yield components had significantly affected (P<0.05) by irrigation systems and water regime.

The number of fruits/m were 30.9, 27.6, 18.5, 34.6, 31.2, and 22.3 due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c, and I2E3c respectively for the growing season 2017/2018 and were 27.40, 23.80, 15.10, 32.60, 29.50, and 19.6 due to the treatments: I1E1c, I1E2c, I1E3c, I2E1c, I2E2c and I2E3c respectively for the second growing season 2018/2019 (Table 5).
The length of fruit were 6.0, 5.8, 4.9, 6.5, 6.1 and 5.3 cm due to the treatments: I1E1, I1E2, I1E3, I2E1, I2E2 and I2E3 respectively for the growing season 2017/2018 and were 5.8, 5.6, 4.5, 6.4, 6.0 and 5.2 cm due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for the growing season 2018/2019 (Table 5).

The diameter of fruit were 4.5, 4.3, 4.1, 5.0, 4.7 and 4.2 cm due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for the growing season 2017/2018 and were 4.3, 4.1, 4.0, 4.9, 4.5 and 3.9 cm due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for the growing season 2018/2019 (Table 5).

The mean values of Fruit size were 48.0, 42.2, 35.0, 65.0, 53.3 and 38.0 cm³ due to the treatments: I1E1, I1E2, I1E3, I2E1, I2E2 and I2E3 respectively for growing season 2017/2018 and were 42.2, 36.9, 33.2, 60.8, 48.3 and 31.5 cm³ due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for growing season 2018/2019 (Table 5).

The mean values of fruit weight (gm) were 48.2, 42.3, 35.6, 64.7, 52.8 and 38.2 gm. due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for growing season 2017/2018 and were 43.1, 36.9, 33.4, 61.1, 49.1 and 31.6 gm. due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for growing season 2018/2019 (Table 5).

The mean values of yield of tree (kg/tree) were 44.1, 41.5, 35.4, 47.2, 45.4 and 38.5 kg/tree due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for the growing season 2017/2018 and were 43.0, 39.7, 31.3, 46.0, 43.9 and 36.5 kg/tree due to the treatments: I1E1, I1E2, I1E3, I1E4, I2E2 and I2E3 respectively for the growing season 2018/2019 (Table 5). The obtained results are in agreement with those expected due to the treatments applied.
obtained by Kumar et al. (2009), Boora et al. (2002) and Singh et al. (2005).

**Reference Evapotranspiration (ET₀), Actual or Crop Evapotranspiration (ETc) and Irrigation Requirements (IR.)**

Table 6 showed that the values of reference or potential evapotranspiration (ET₀ or ETₚ) are affected by the climatic factors, and has ET₀ increased in summer and decreased in winter. Maximum values of ET₀ or ETₚ were found in July (5.69 and 5.73 mm/day) in 2017 / 2018 and 2018 / 2019 seasons, respectively. Minimum value of ET₀ or ETₚ was found in December 2017/2018 (1.50 mm/day) while minimum value of ET₀ (1.48 mm/day) was found in January 2018/2019.

It is clear from the obtained data, that daily and monthly crop or actual evapotranspiration (ETc) had the same behavior as reference evapotranspiration (ET₀), where the values of daily and monthly ETc had increased in summer and decreased in winter. Maximum values of daily ETc or ETc were found in July (4.78 and 4.81 mm/day) in 2017 / 2018 and 2018 / 2019 seasons, respectively. Minimum values of daily ETc or ETc were found in December (0.83 and 0.87 mm/day in 2017 / 2018 and 2018 / 2019 seasons, respectively). Cumulative crop evapotranspiration in the first growing season (2017/2018) was 1060.29 mm, while in second growing season (2018/2019) was 1043 mm. These findings agreed with the data obtained by Gad El-Rab et al. (1993), Attia et al. (1994) and Abbas and Anton (1999).

Table 6 showed that irrigation requirements of guava had ascending values during January - July and descending values during August - December. Cumulative irrigation requirements (IR.) of the first growing season (2017/2018) recorded 963.59 mm, while in the second growing season (2018/2019) it recorded 922 mm. The obtained results are in agreement with those obtained by Pouget (1981), Kliwer (1977), Kliwer (1971) and Kliwer and Schultz (1973).

**Table 6. Monthly reference evapotranspiration (ET₀), crop evapotranspiration, effective rainfall and irrigation requirements during the two growing seasons: 2017 / 2018 and 2018 / 2019**

| Months | ET₀ (mm/day) | Kc | ETc (mm/day) | ETc (mm/month) | Effective Rainfall (mm/month) | Irr. Req. (mm/month) |
|--------|--------------|----|--------------|----------------|-----------------------------|---------------------|
|        |              |    |              |                |                             |                     |
| Jan.   | 1.52         | 0.85| 1.29         | 39.99          | 13.60                       | 26.39               |
| Feb.   | 2.19         | 0.85| 1.86         | 52.08          | 11.80                       | 40.28               |
| Mar.   | 3.14         | 0.85| 2.67         | 82.77          | 1.50                        | 81.27               |
| Apr.   | 4.09         | 0.86| 3.52         | 105.60         | 2.80                        | 102.80              |
| May    | 4.97         | 0.86| 4.27         | 132.37         | 0.00                        | 132.37              |
| June   | 5.43         | 0.86| 4.67         | 140.09         | 0.00                        | 140.09              |
| July   | 5.69         | 0.84| 4.78         | 148.17         | 1.70                        | 146.47              |
| Aug.   | 5.38         | 0.81| 4.36         | 135.16         | 0.00                        | 135.16              |
| Sep.   | 4.52         | 0.70| 3.16         | 94.80          | 0.00                        | 94.80               |
| Oct.   | 3.23         | 0.66| 2.13         | 66.03          | 10.90                       | 55.13               |
| Nov.   | 2.09         | 0.60| 1.25         | 37.50          | 22.50                       | 15.00               |
| Dec.   | 1.50         | 0.55| 0.83         | 25.73          | 46.80                       | (-21.07 )           |
| Σ      |              |    |              | 1060.29        | 111.70                      | 963.59              |
|        |              |    |              |                |                             |                     |
| Jan.   | 1.48         | 0.85| 1.26         | 35.28          | 24.00                       | 11.08               |
| Feb.   | 2.08         | 0.85| 1.77         | 49.50          | 14.00                       | 35.00               |
| Mar.   | 2.96         | 0.85| 2.52         | 78.00          | 24.30                       | 53.7                |
| Apr.   | 3.88         | 0.86| 3.35         | 100.50         | 3.50                        | 97.00               |
| May    | 4.71         | 0.86| 4.05         | 125.55         | 0.00                        | 125.55              |
| June   | 5.57         | 0.86| 4.79         | 143.71         | 0.00                        | 143.71              |
| July   | 5.73         | 0.84| 4.48         | 149.21         | 0.00                        | 149.21              |
| Aug.   | 5.44         | 0.81| 4.41         | 136.71         | 0.00                        | 136.71              |
| Sep.   | 4.46         | 0.70| 3.12         | 93.66          | 0.00                        | 93.66               |
| Oct.   | 3.22         | 0.66| 2.13         | 66.03          | 17.40                       | 48.63               |
| Nov.   | 2.15         | 0.60| 1.29         | 38.70          | 0.20                        | 38.50               |
| Dec.   | 1.58         | 0.55| 0.87         | 26.97          | 37.60                       | (-10.63 )           |
| Σ      |              |    |              | 1043           | 121                         | 922                 |
Amount of applied irrigation water and crop water use efficiency:

Amount of applied irrigation water (AIW)

Table 7 showed that the amount of AIW, for the treatments I1E1, I1E2 and I1E3 have recorded 1550.39, 1240.31 and 930.23 mm. respectively in the 1st growing season, and 1474.90, 1179.94 and 884.95 mm. respectively in the 2nd growing season. The results of AIW for the treatments I2E1, I2E2 and I2E3 were 1138.88, 911.10 and 683.33 mm. respectively in the 1st growing season, and were 1040.15, 832.13 and 624.09 mm. respectively in the 2nd growing season.

At the beginning of the growing season, the amount of applied water was low then and increased due to increasing vegetative growth of guava plant. However, the amounts of applied water declined at maturity.

Maximum value of AIW (249.18 mm / month) for guava trees was recorded in July at 2018/2019 by applying 100% of ETc and furrow irrigation (I1E1), while minimum value of AIW (24.78 mm / month) occurred in February at the growing season 2018/2019 by applying 60% of ETc and drip irrigation (I3E3). These results are in agreement with those reported by Ekren et al. (2012) and Ibrahim (2003).

**Water use efficiency (WUE):**

The furrow irrigation method used higher amounts of water than drip irrigation method (Table 8). Water use efficiency of drip-irrigated treatment was higher and differed from furrow irrigated treatment in the two growth seasons (P<0.05). Maximum water use efficiency (3.34 kg.m⁻³) was recorded in guava trees as a result of I1E3 treatment (60% ETc + drip irrigation) in the 2nd season 2018/2019 (Fig.1).

### Table 7. Applied irrigation water (AIW, mm / month) for guava trees, as affected by irrigation systems and water regime during the two growing seasons, 2017/2018 and 2018/2019

| Month | 100% ETc | 80% ETc | 60% ETc | 100% ETc | 80% ETc | 60% ETc |
|-------|----------|---------|---------|----------|---------|---------|
|       | (E1)     | (E2)    | (E3)    | (E1)     | (E2)    | (E3)    |
| 2017/2018 |          |         |         |          |         |         |
| Jan.  |          |         |         |          |         |         |
| Feb.  | 67.27    | 53.82   | 40.12   | 47.35    | 37.88   | 28.41   |
| Mar.  | 135.72   | 108.58  | 81.43   | 95.90    | 76.72   | 57.54   |
| Apr.  | 171.68   | 137.34  | 103.01  | 121.3    | 97.04   | 58.22   |
| May   | 221.06   | 176.85  | 132.64  | 156.20   | 124.96  | 93.72   |
| June  | 233.95   | 187.16  | 140.37  | 165.31   | 132.25  | 99.19   |
| July  | 244.60   | 195.68  | 146.76  | 172.83   | 138.26  | 103.70  |
| Aug.  | 225.72   | 180.58  | 135.43  | 159.49   | 127.59  | 95.69   |
| Sep.  | 158.32   | 126.66  | 94.99   | 111.86   | 89.49   | 67.12   |
| Oct.  | 92.07    | 73.66   | 55.24   | 108.64   | 86.91   | 65.18   |
| Nov.  |          |         |         |          |         |         |
| Dec.  |          |         |         |          |         |         |
| Σ     | 1550.39  | 1240.31 | 930.23  | 1138.88  | 911.10  | 683.33  |

| 2018/2019 |          |         |         |          |         |         |
| Jan.  |          |         |         |          |         |         |
| Feb.  | 58.45    | 46.76   | 35.07   | 41.30    | 33.04   | 24.78   |
| Mar.  | 89.68    | 71.74   | 53.81   | 63.37    | 50.70   | 38.02   |
| Apr.  | 161.99   | 129.59  | 97.19   | 114.46   | 91.57   | 68.68   |
| May   | 209.67   | 167.74  | 125.80  | 146.15   | 116.92  | 87.69   |
| June  | 240.00   | 192.00  | 144.00  | 169.58   | 135.66  | 101.75  |
| July  | 249.18   | 199.34  | 149.51  | 176.07   | 140.86  | 105.64  |
| Aug.  | 228.31   | 182.65  | 136.99  | 161.32   | 129.06  | 96.79   |
| Sep.  | 156.41   | 125.13  | 93.85   | 110.52   | 88.42   | 66.31   |
| Oct.  | 81.21    | 64.99   | 48.73   | 57.38    | 45.90   | 34.43   |
| Nov.  |          |         |         |          |         |         |
| Dec.  |          |         |         |          |         |         |
| Σ     | 1474.90  | 1179.94 | 884.95  | 1040.15  | 832.13  | 624.09  |
Effect of Irrigation Systems and Water Regime on Growth, Yield Components, Water Use Efficiency…

Table 8. The mean values of water use efficiency (WUE) mean values, as affected by irrigation systems and water regime during the two growing seasons

| Treatments | Water use efficiency (kg/m³) |
|------------|-----------------------------|
|            | 1st season                  | 2nd season                  |
| I₁E₁       | 1.63                        | 1.67                        |
| I₁E₂       | 1.91                        | 1.92                        |
| I₁E₃       | 2.18                        | 2.03                        |
| I₂E₁       | 2.37                        | 2.53                        |
| I₂E₂       | 2.58                        | 3.02                        |
| I₂E₃       | 2.33                        | 3.34                        |
| LSD₀.₀₅    | 0.21                        | 0.18                        |

Fig 1. Effect of irrigation systems and water regime on crop water use efficiency (kg/m³) of guava (Psidium Guavaja L.) during the two growing seasons (2017 / 2018 and 2018 / 2019)

Water use efficiency ranged from 1.63 to 3.34 kg.m⁻³ and increased with the decreasing applied water in the two growing seasons. Alaa et al. (2012) concluded that WUE increased from 5.129 to 7.379 kg.m⁻³ for furrow-irrigated treatment, and from 6.907 to 10.257 kg.m⁻³ for drip-irrigated treatments.

Fruit chemical composition

The chemical analysis of guava fruits included; total soluble solids (TSS %), acidity (%), TSS / Acidity ratio and vitamin C (mg / 100 g pulp) and were shown in Table 9 and Figs 2 and 3.

Total soluble solids (TSS %):

The mean values of TSS were 11.75, 11.32, 10.99, 12.23, 11.99 and 11.02% due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the growing season 2017/2018 and were 11.72, 11.16, 10.65, 12.62, 12.03 and 10.42% due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the growing season 2018/2019.

Acidity (%):

The mean values of acidity were 0.48, 0.45, 0.36, 0.53, 0.48 and 0.43% due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the 1st growing season (2017/2018) and were 0.44, 0.41, 0.35, 0.49, 0.46 and 0.37% due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the 2nd growing season (2018/2019). The maximum acidity (0.53%) was recorded in guava trees due to the I₂E₁ treatment (100 %ETc + drip irrigation) in the 2nd season 2018/2019.
TSS / Acidity ratio:

The mean values of this ratio were 24.48, 25.16, 29.92, 23.08, 24.98 and 25.65 due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the 1st growing season (2017/2018) and were 26.64, 27.21, 30.43, 25.76, 26.15 and 28.16 due to the treatments: I₁E₁, I₁E₂, I₁E₃, I₂E₁, I₂E₂ and I₂E₃, respectively for the 2nd growing season 2018/2019.

Maximum TSS / Acidity ratio (30.43) was recorded in guava trees under I₁E₃ the treatment (60 %ETc + furrow irrigation) in the 1st season (2017/2018) and the minimum TSS / Acidity ratio (23.08) was recorded in guava trees under I₂E₁ the treatment (100 %ETc + drip irrigation) in the 2nd season 2018/2019.

Table 9. Effect of irrigation systems and water regime on chemical composition of guava (Psidium Guavaja L.) during the two growing seasons: 2017 / 2018 and 2018 / 2019

| Treatments | TSS (%) | Acidity (%) | TSS / acidity Ratio | Vitamin C (mg/100 g pulp) |
|------------|---------|-------------|---------------------|--------------------------|
|            | 2017 / 2018 |                             |                     |                          |
| I₁E₁       | 11.75   | 0.48        | 24.48               | 47.44                    |
| I₁E₂       | 11.32   | 0.45        | 25.16               | 47.21                    |
| I₁E₃       | 10.77   | 0.36        | 29.92               | 46.09                    |
| I₂E₁       | 12.23   | 0.53        | 23.08               | 49.46                    |
| I₂E₂       | 11.99   | 0.48        | 24.98               | 48.21                    |
| I₂E₃       | 11.02   | 0.43        | 25.14               | 46.54                    |
| LSD₀.₀₅    | NS      | NS          | NS                  | 1.96                     |
|            | 2018 / 2019 |                             |                     |                          |
| I₁E₁       | 11.72   | 0.44        | 26.64               | 49.52                    |
| I₁E₂       | 11.16   | 0.41        | 27.21               | 48.42                    |
| I₁E₃       | 10.65   | 0.35        | 30.43               | 46.51                    |
| I₂E₁       | 12.62   | 0.49        | 25.76               | 50.34                    |
| I₂E₂       | 12.03   | 0.46        | 26.15               | 49.63                    |
| I₂E₃       | 10.42   | 0.37        | 28.16               | 46.79                    |
| LSD₀.₀₅    | NS      | NS          | NS                  | 2.03                     |

Fig 2. Effect of irrigation systems and water regime on chemical composition of guava (Psidium Guavaja L.) during the first growing season 2017 / 2018
Ashraf E. Elnama: Effect of Irrigation Systems and Water Regime on Growth, Yield Components, Water Use Efficiency…. 269

Fig 3. Effect of irrigation systems and water regime on chemical composition of guava (Psidium Guajava L.) during the second growing season 2018 / 2019

Vitamin C (mg/100 g pulp):
The obtained data for vitamin C showed that significant effect of irrigation systems and water regime during growing seasons 2017/2018 and 2018/2019 (Table 9). The highest vitamin C content was found under I1E1 and I2E3 treatments and recorded 49.46 and 48.21 mg/100 g pulp in the 1st growing season, respectively and recorded 51.34 and 49.63 (mg/100 g pulp) in the 2nd growing season, respectively. The lowest vitamin C content was found under I1E3 and recorded 45.09 mg/100 g pulp in the 1st growing season, while in the 2nd growing season was the lowest value under I2E3 and recorded 46.79 mg/100 g pulp.

Our results can be confirmed by those found by Khattab et al. (2011) and Lawand and Patil (1996) who found non-significant effect of different water regimes on TSS (%), acidity (%), while significant effect on Ascorbic acid.

Economic Analysis
Table 10 and Figs 4 and 5 showed that total cost of guava production has been affected by the various treatments which can be arranged as follows: I1E1 > I2E1 > I2E2 > I2E3 > I1E3 in the 1st season, and was I1E1 > I2E1 > I1E2 > I1E3 > I2E2 > I2E3 in 2nd season.

Table 10. Economic analysis of guava grown under irrigation systems and water regime treatments during the two growing seasons (2017/2018 and 2018/2019)

| Treatments | Total cost (LE/fed.) | Total return (LE/fed.) | Net return (LE/fed.) | W.P. (LE/m³) |
|------------|----------------------|------------------------|----------------------|--------------|
|            | 2017 / 2018          |                        |                      |              |
| I1E1       | 10510                | 31740                  | 21230                | 3.26         |
| I1E2       | 9208                 | 24900                  | 15690                | 3.01         |
| I1E3       | 8279                 | 17000                  | 8721                 | 2.23         |
| I2E1       | 9279                 | 33990                  | 24711                | 5.16         |
| I2E2       | 8326                 | 27250                  | 18924                | 4.95         |
| I2E3       | 8357                 | 18460                  | 10103                | 3.52         |
|            | 2018 / 2019          |                        |                      |              |
| I1E1       | 10174                | 30960                  | 20786                | 3.37         |
| I1E2       | 8952                 | 23825                  | 14873                | 3.00         |
| I1E3       | 8696                 | 15040                  | 6344                 | 1.71         |
| I2E1       | 8868                 | 33150                  | 24282                | 5.56         |
| I2E2       | 7994                 | 26325                  | 18331                | 5.25         |
| I2E3       | 7520                 | 17500                  | 9980                 | 3.81         |
Fig 4. Economic analysis of guava as influenced by irrigation systems and water regime during the growing season 2017 / 2018

The maximum value of total return was recorded due to T_2E_1 treatment for the two growing seasons and the minimum value of total return was recorded as a result of I_1E_3 treatment for the two growing seasons. Net return has the same trend of total return in the two growing seasons. Table 10 showed that water productivity (W.P.) has been affected by both irrigation systems and water regime.

The maximum values of water productivity (W.P.) were 5.16 and 4.95 LE/ m³ under I_2E_1 and I_3E_2,
respectively in the 1st growing season (2017/2018) and recorded 5.56 and 5.25 LE/ m³ under I₁E₁ and I₂E₁, respectively in the 2nd growing season (2018/2019). The lowest water productivity was obtained under I₁E₃ treatment, which recorded 2.23 and 1.71 LE/ m³, respectively for the two growing season: 2017/2018 and 2018/2019.

CONCLUSION

The results obtained in this study indicated that surface drip irrigation with 100% ETc and 80% of ETc produced higher yield and yield components of guava trees. The highest values of shoot length, number of leaves/m and leaf area were obtained as a result of I₁E₁ treatment (SDI (I₂ + 100% ETc) while the lowest values were due to I₁E₃ treatment (furrow irrigation and 60% ETc). The highest values of WUE and water productivity (W.P.) were obtained by I₁E₁ and I₂E₂ treatments in the two growing seasons, while the lowest values of WUE and water productivity (W.P.) were obtained by I₁E₂ treatment (furrow irrigation and 100 % ETc). It is clear, therefore, that I₁E₁ (drip irrigation with 100% ETc) and I₂E₂ (drip irrigation with 80% ETc) treatments can be considered the most effective irrigation method with water regime application in improving WUE and increasing yield, yield components and water productivity of guava trees.

It is recommended through the results of this research to replace surface irrigation with drip irrigation with water regime 100% or 80%. Also, future study should be carried out to evaluate the effect of drip irrigation on clay soil, other plants and its impact on the environments.

REFERENCE

A.O.A.C. 1975. Association of Official Agricultural Chemists. “Official Methods of Analysis”. 12th Ed., Published by AOAC, Washington D.C., USA.

A.O.A.C. 1995. “Official Methods of Analysis”. 16th Ed., Association of Official Analytical Chemists, International, Virginia, USA

Abbas, F.A. and N.A.Anton . 1999. Effect of irrigation intervals on sunflower production. 3rd Conf. of On Farm Irrigation and Agro climatology Vol.(1):pp.633-646 , January 25-27.1999,Egypt.

Abdel-Mawgoud, A.M., M.A. El-Nemr, A.S. Tantawy, and H.A. Habib.2010. Alleviation of salinity effects on green bean plants using some environmental friendly materials. J. Appl. Sci. Res. 6: 871–878.

Agrawal, N.and S. Agrawal .2007. Effect of different levels of drip irrigation on the growth and yield of pomegranate under Chhattisgarh Region. Orissa. J. Hort. 35:38-46.

Alaa, S. A., D.L. Ammar and M. N. Salah.2012. “Water use efficiency of potato (Solanum tuberosum L.) under different irrigation methods and potassium fertilizer rates”. Annals of Agricultural Sciences Volume 57, Issue 2, December 2012, Pages 99-103.

Atia, M. M., A. M. Osman, M.A. Sayed and A.A. El Kafory .1994. Effect of irrigation interval and plant density on sunflower yield in calcareous soil of West Nubaria region. J. Agric. Sci., Mansoura Univ., 19 (10): 3163-3168.

Badr, M.A., S.D. Abou Hussein, W.A. El-Tohamy and N. Gruda.2010. Efficiency of subsurface drip irrigation for potato production under different dry stress conditions. Gesunde Pflanzen . 62: 63–70.

Bharambe, P.R., M.S. Mungal, D.K. Shelke, S.R. Oza, V.G. Vaishnava and V.D. Sondge .2001. Effect of soil moisture regimes with drip on spatial distribution of moisture, salts, nutrient availability and water use efficiency of banana. J. Ind. Soc. Soil Sci. 49:658-665.

Bisbis, M.B., N. Gruda and M. Blanke .2018. Potential impacts of climate change on vegetable production and product quality—A review. J. Clean. Prod. 170: 1602–1620.

Biswas, R.K., S.K. Rana, and S. Mallick. 1999. Performance of drip irrigation in papaya cultivation in new alluvio agro-climatic zone of West Bengal. Annals of Agri. Res., 20(1): 116-117.

Black C. A. (ed.). 1965. Method of Soil Analysis, Part 2, Chemical and Microbiological Properties, American Society of Agronomy, Inc, Publisher, Madison, Wisconsin USA.

Boora, R.S., D. Singh, S. Siddiqui and S.L. Verma .2002. Response of sapota to NPK fertilization. Haryana. J. Hort. Sci. 31:15-17.

Doorenbos, J. and W.O.Pruitt.1984. Guidelines for Predicting Crop Water Requirements. Irrigation and Drainage, Paper 24 FAO of UN, Rome, Italy.7.

Durwish, K.H., M. Safaa, A. Momou and S.A. Saleh .2013. Egypt: Land degradation issues with special reference to the impact of climate change. In Combating Desertification in Asia, Africa and Middle East, Proven Practices; Heshmati G.A. and V.R. Squires .2013. Eds.; Springer: Dordrecht, The Netherlands, Chapter 6. pp. 113–136.

Ekren, S., C. Sonmez, E. Ozcakal, Y.S.K. Kurttas, E. Bayram and H.Gurgulu .2012. The effect of different irrigation water levels on yield and quality characteristics of purple basil (Ocimum basilicum L.). Agric. Water Manage. 109: 155–161.

El-Dakrouy, MAE. 2008. “Influence of different irrigation systems and treatments on productivity and fruit quality of some bean varieties”. M.Sc. Thesis, Faculty of Agriculture, Tanta University, Egypt: 94.

FAO. 1998. Crop evapotranspiration, guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56. FAO. Rome.
Farooq, M., A.Wahid, N. Kobayashi, D.Fujita and S.M.A. Basra. 2009. “Plant drought stress: effects, mechanisms and management”. Sustainable Agriculture Springer, Netherlands, 29 (1):185-212.

Gad El-Rab, G.M., N.G.Ainer and Mahmoud S.A. 1993. Effect of drought conditions at different growth periods on sunflower yield and water use. J. Agric. Sci., Mansoura Univ., 19 (10): 3163-3168.

Horwitz W. 1970. Official methods of Analysis. Association of Official Analytical Chemists, 11th Ed., Washington D.C., USA.

Ibrahim, El.G. 2003. Productivity, water use and yield efficiency of banana under different irrigation systems and water quality in sandy soil. Egypt J. Appl. Sci. 18(10):334-348.

Israelen, O.W. and V.E. Hansen. 1962. Irrigation principles and practices. 3rd Ed. John Wiley and Sons. Inc. New York.

Khattab, M.M., A.E. Shaban, A. H. El-Shrief and M. A.S. El-Deen. 2011. Growth and productivity of pomegranate trees under different irrigation levels. II: fruit quality. J. Hortic. Sci. Ornam. Plants. 3(3): 259-264.

Kliewer, W. M. 1977. Effect of high temperature during the bloom-set period on fruit-set, ovule fertility, and berry growth of several grape cultivars. American Journal of Enology and Viticulture 28:215-221.

Kliewer, W. M. and H. B. Schultz. 1973. Effect of sprinkler cooling of grapevines on fruit growth and composition. Am. J. Enology Viticulture 24:17-26.

Kliewer, W. M. 1971. Effect of temperature on the composition of cabernet sauvignon berries. Am. J. Enology Viticulture 22:71-75.

Kumar, A., H. K. Singh, N. Kumari, and P. Kumar. 2009. Effect of fertigation on banana biometric characteristics and fertilizer use efficiency. Agri. Engineering, ISAE. 46(1): 27-31.

Lawand, B.T. and V.k. Patil. 1992. Effect of different water regimes on fruit quality of pomegranate (Punica granatum L.). Acta Hortic.. 321: 677-683

Leilah A.A. 2009. “Physiological response of onion to water stress and bio fertilizers”. M.Sc. Thesis, Faculty of Agriculture, Mansoura University, Egypt: 121.

Michael A.M. 1978. Irrigation theory and practice. Vikas Publishing House PVT LTD New Delhi, Bombay.

Mutava, R., S. Prince., N. Syed, L. Song, B.Valliodan, W. Chen and H. Nguyen. 2015. “Understanding abiotic stress tolerance mechanisms in soybean: A comparative evaluation of soybean response to drought and flooding stress”. Plant Physiol and Biochem 86: 109-120.

Ouda, S. 2016. Major Crops and Water Scarcity in Egypt: Irrigation Water Management under Changing Climate; Springer: Cham, Switzerland; ISBN 978-3-319-21771-0.

PAGE, A. L., R. H. MILLER and D. R. KEENEY, (Ed.), 1982 Methods of Soil Analysis. Part 2. American Society of Agronomy, Madison, Wisconsin, USA.

Patil, P.V. and V.K. Patil. 1999. Influence of different soil water regimes on root distribution in guava. J. Maharashtra. Agric. Univ. 24:45-47.

Pouget, R. 1981. Action de la temperature sur la differenciation des inflorescences et dus fleurs durant les phases de pre debourrement et de post debourrement des bourgeons latents de la Vigne. Conn. Vigne Vin 15:65-79.

Saleh, S.A., Z.S. El-Shal, Z.S. Fawzy and A.M. El-Bassiony. 2012. Effect of water amounts on artichoke productivity irrigated with brackish water. Aust. J. Basic Appl. Sci. 6: 54–61.

Salvin, S., K. Baruah and S.K. Bordoloi. 2000. Drip irrigation studies in banana cv. Barjahaji (Musa AAA group, Cavendish sub-group). Crop Res. 20:489-493.

SAS Institute, 1996. SAS/STAT user’s Guide version 6.4th ed SAS Institute Inc. Cary, NC, USA.

Singh, H.K., A.K.P. Singh and A.K. Sinha. 2005. Effect of fertigation on fruit growth and yield of papaya with drip irrigation. Haryana. J. Hort. Sci. 34:7-8.

Singh H.P. 2005. Micro irrigation for sustainable agriculture. National Conference on Micro irrigation held at GBPUA&T, Pantnagar, India. 3-5 June 2005.

Stanhill G. 1986. Water use efficiency. Adv. Agron. 39: 53–85.

Vites, Jr., F.G. 1962. Fertilizers and the efficient use of water. Adv. Agron. 14: 223–264.

Vomocil J.A. 1957. Measurements of soil bulk density and penetrability. A review of method Adv. Agron. 9: 159-176.

Wide, S., R. B. Corey, J. G. Lyer and G.Viogte.1985. Soil and Plant Analysis for Tree Culture, 3rd Ed., Oxford, IBH Publishing Co., New Delhi, pp. 93-116.

Zhang, C. and Z. Huang. 2013. “Effects of endogenous abscisic acid, jasmonic acid, polyamines, and polyamine oxidase activity in tomato seedlings under drought stress”. Scientia Hort. 159: 172-177.
تأثير نظام الري والرژيم المائي على كلا من النمو ومكونات المحصول وكفاءة استخدام الماء والانتاجية المائية للجوافة المنزرعة في التربة الطينية

أشرف السيد النماس

أجريت تجارب حقلية خلال موسمين زراعيين متتاليين (2017/2018 و 2018/2019) في بستان الجوافة بمدينة كفر الدوار ، محافظة البحيرة . جمهورية مصر العربية للتحقق من تأثير كلا من الرژيم المائي (100% , 80% , 60% من اليرش المحصولي ) و نظامي الري (الرى بالخطوط , الرى بالتنقيط) على كفاءة استخدام المياه و نمايات النمو و معايير النمو و مكونات المحصول، و التحليل الاقتصادي لأشجار الجوافة البالغة من العمر أربع سنوات المنزرعة في التربة الطينية . تم تنفيذ التجربة في تصميم القطاعات العشوائية الكاملة بثلاثة مكررات .

تم تسجيل نتائج عدم وجود فروق معنوية للخصائص الكيميائية لثمار محصول الجوافة والتي تشمل على المكونات الصلبة الكلية والحموضة، ونسبة بين الصلبة الكلية والحموضة . وكان أقصى صافي عائد (24411 جنيه / فدان) خلال موسمى النمو (2017/2018 و 2018/2019) عند تطبيق نظام الري بالتنقيط و100% من اليرش المحصولي، بينما أقل صافي عائد (6344 جنيه / فدان) عند تطبيق نظام الري السطحي بالخطوط و 60% من اليرش المحصولي . تراوحت قيم كفاءة استخدام المياه بين 2.3 و 3.34 كجم/م³ تحت معاملة الري بالتنقيط بينما تراوحت بين 1.6 و 2.18 كجم/م³ في معاملة الري بالخطوط خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب .

كانت كفاءة استخدام المياة لمعاملة الري بالتنقيط أعلى عند مقارنتها مع معاملة الري السطحي خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب .

من البخارنتح المحصولي أعطى أقصى طول غصن (3.59 سم) . كان أقصى محصول جوافة عند تطبيق معاملة الري بالتنقيط و100% من البخارنتح المحصولي (11.33 طن / فدان) خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب بينما أقل محصول (8.50 طن / فدان) خلال موسمي النمو (2017/2018 و 2018/2019) على الترتيب .

كما وجدت اختلافات معنوية بين مكونات المحصول والتي تشمل على

عدد الأوراق لكل غصن ، طول الورقة (سم) ، حجم الفسيلة (سم³) و المحصول (جم / فدان) . كانت كفاءة استخدام المياه لمعاملة الري بالتنقيط أعلى عند مقارنتها مع معاملة الري السطحي خلال موسمى النمو . حيث ذات قيم كفاءة استخدام المياه من 2.3 و 3.34 كجم/م³ تحت معاملة الري بالتنقيط بينما تراوحت بين 1.6 و 2.18 كجم/م³ في معاملة الري بالخطوط خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب .

تم تسجيل نتائج عدم وجود فروق معنوية للخصائص الكيميائية لثمار محصول الجوافة والتي تشمل على المكونات الصلبة الكلية والحموضة، ونسبة بين الصلبة الكلية والحموضة . كان أقصى صافي عائد (24411 جنيه / فدان) خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب .

من البخارنتح المحصولي أعطى أقصى طول غصن (3.59 سم) . كان أقصى محصول جوافة عند تطبيق معاملة الري بالتنقيط و100% من البخارنتح المحصولي (11.33 طن / فدان) خلال موسمى النمو (2017/2018 و 2018/2019) على الترتيب بينما أقل محصول (8.50 طن / فدان) خلال موسمي النمو (2017/2018 و 2018/2019) على الترتيب .

نجم النظام السطحي باستثناء حجم الفسيلة ، حيث أعطى أقصى حجم الفسيلة (5.56 جم / م³) عند تطبيق نظام الري بالتنقيط و80% من البخارنتح المحصولي (2018/2019) على الترتيب .

نجم النظام السطحي باستثناء حجم الفسيلة ، حيث أعطى أقصى حجم الفسيلة (5.56 جم / م³) عند تطبيق نظام الري بالتنقيط و80% من البخارنتح المحصولي (2018/2019) على الترتيب .