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The Effect of Deficit Irrigation Levels on Squash at different Growth Stages

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The effect of irrigation during different growth stage (vegetation, flowering and yielding) on Zucchini yield "Mabroka" was estimated in this research. The field experiments were carried out at privet sector farm in Beheira Governorate, along two seasons in 2016 and 2017 under sand soil conditions, where some different deficit irrigation variants were applied. Drip irrigation system with emitters discharge of 4.0 $l \cdot h^{-1}$ Every 3 days was used. The different influence of deficit irrigation was observed on the Zucchini yielding during the whole cultivation period, the results showed that, 100% ET_o (water applied 280 L/m^2) gave the highest yield 48.1 Ton/ha with water use efficiency (WUE) 18.15 Kg/m^3, irrigated during vegetative growth till setting fruitlets100% ET_o and 80% ET_o irrigated during yielding (water applied 245 L/m^2) gave yield 45 Ton/ha with WUE 19.42 Kg/m^3, 80% ET_o irrigated during a whole vegetative period and irrigated 100% ET_o during yielding from the phase of fruits setting (water applied 250 L/m^2) gave yield 39 Ton/ha with WUE.16.09Kg/m^3 and whole cultivation period 80% ET_o(water applied 224 L/m^2) gave the smallest yield 36.8Ton/ha with WUE 17.38 Kg/m^3. Optimizing humidity conditions during intensive growth of Zucchini, from seedlings into the field till the beginning of fruiting, it was possible to obtain the biggest yield of fruits as well as extend the harvest.

Keywords: Squash, Cucurbita pepo L., drip irrigation, harvest, stage of growth, ET_o.

INTRODUCTION

Zucchini (Cucurbita pepo L.) is considered one of the most important vegetable crops in the world due to it being a commercial crop for fields and greenhouses. The major area for growing Zucchiniis Mediterranean countries as one of the main vegetables (Mohammad 2004), and is also a widely grown and consumed vegetable in Egypt. The planted area of summer Zucchiniin Egypt was 37815 ha in 2015 and production was 850000 ton (MALR, 2015). It is grown during all seasons expect winter by using both drip and furrow irrigation methods (Amer 2011). (Khalil et al., 1996 and Amer 2011) found that the total yield of Zucchini was significantly higher for the drip irrigation method compared to the furrow irrigation method. (Ahmet et al., 2004) using furrow irrigation on Zucchini found that fruit yield significantly increased in linear relationship from 22.4 to 44.7Mgha−1 as irrigation water applied increased from 279 to 475mm in deficit irrigation where no deep percolation occurred. (Al-Omran et al., 2005) studied Zucchini using both surface (DI) and subsurface drip irrigation (SDI) methods in sandy soils with three clay deposits found that fruit yield has a linear relationship to increased irrigation water level for each season within the same treatment. They found that fruit yields significantly increased with clay deposits compared with control. The differences between SDI and DI on fruit yields were also significant. Water use efficiency linearly increased as irrigation water applied increased for deficit

irrigation level and decreased for excessive irrigation level. A Zucchini (Cucurbita pepo L.) is an annual plant of a big commercial importance. It is a high yield vegetable that provides a valuable raw material for processing industry. Summer Zucchinihas a shallow rooting system depth and is sensitive to moisture in the soil. Increasing water stress probably damage fruits and roots (Ertek *et al*. 2004; Amer 2011); therefore, good draining soils are suitable for summer zucchini. Zucchiniis is an important commercial crop that has gained popularity for both open-field and greenhouse in the Mediterranean region (Rouphael and Colla, 2005). Zucchiniis normally grown in

soil under conditions using both trickle and furrow irrigation methods during the spring-summer and the summer–fall seasons in order to respond to the high demand of this fresh product on both national and international markets. The soil water Drain for the prevention of stress has to be below 0.50 (Savva and Frenken 2002). A considerable development of Zucchini cultivation in Poland has been observed in the last few years. Big popularity of Zucchini cultivation results from big progress in its breeding, providing new big assortment of valuable cultivars and mainly thanks to describing a flowering biology of this plant [Mancini and Calabrese 1999]. The optimal period for female flowers development is in the conditions of a short day and low temperatures and optimal conditions of soil humidity [NeSmith et al. 1994]. Most cultivar reacts to increase of temperature to 30°C initiating male flowers (Suleiman and Suwwan 1990). Flowers differentiation is usually finished before the plant forms two true leaves [Hume and Novell 1983].In Zucchini cultivation very significant inhibition of growth of plants at insufficient water supply has been observed (Dweikat and Kostewicz 1989). Requirement and consumption of water during growth is different. Depending on the length of period of water shortage different reactions of plants can be observed. The first symptom is wilting resulting from turgor decrease what causes lowering intensity of photosynthesis. This phenomenon often appears in summer when, due to high sunlight and hot wind gusts in the afternoon hours, transpiration is higher than water absorption [Khalil et al. 1996]. Zucchini has the biggest water requirements during setting and growing of fruits – the humidity of soil should not decrease below 80–85% of field water capacity (Kaniszewski 2005). In experiments relating to irrigation of Cucurbitaceae plants the increase of yield and high effectiveness of both drip irrigation and micro-sprinkling were proven (Kaniszewski and Elkner 2002, Kaniszewski 2005). The yield of Zucchini increased on average by 85% due to irrigation, while for Cucurbita maxima L. it increased on average by 61% with drip irrigation and by 73% with micro-sprinkling (Rolbiecki and Rolbiecki 2005, Rolbiecki et al. 2005). The aim of the work was the evaluation of irrigation effect applied in different phases of growth on Zucchini cultivar 'Mabroka' yielding. (El-Gindy et al. 2009) showed that a higher irrigation quantity (80% of ET_{crop}) provided higher fresh yields, fruit diameters, fruit numbers per plant and fruit lengths in drip-irrigated summer Zucchini comparative with to those with a lowest irrigation quantity (60% of ET_{crop}). Al-Omran et al. (2005) indicated that the fruit yield of Zucchini irrigated at four irrigation levels (60%, 80%, and 100% 120% of ET_o - Estimated Crop Evapotranspiration) in Riyadh, Saudi Arabia, was significantly affected by increasing irrigation quantities. Although yield was increased at higher irrigation levels (100% ETo and 120% ETo), it was significantly reduced at lower irrigation levels (60% ETo and 80% ETo). Also, WUE values were generally increased with irrigation quantity, but decreased at the highest irrigation level.

MATERIALS AND METHODS

The experiment was conducted with four replications undertaken in the years 2016–2017 as a strict field experiment on a Zucchini plantation in privet sector farm, Beheira Governorate as a sand soil. The field experiment was established in a randomized Experimental plots were arranged as 8.4 m long and 2.4 m wide. Plots were surrounded by a 1.5 m dry area to prevent the passage of water from adjacent plots. Summer Zucchini (Cucurbita pepo L.) hybrid Mabroka variety seedlings were planted in 4 rows in each plot on 28th May. The planting distances were 60x60 cm (Dweikat and Kostewicz 1989), both between and within rows, and there were 56 plants in each plot. Water requirement were calculate four irrigation treatments based on crop evapotranspiration (ET_0), including irrigation by 100% of ET_0 in the soil (control treatment) were studied in a Complete Randomized Block Experimental Design with three replicates (ETc) of Zucchini crop was calculated as follows:

$ETc = ETo * Kc$

Where:

ETc: Crop water requirement or the actual evapotranspiration (mm/day),

ETo: Reference evapotranspiration (mm/day) and

Kc : Crop coefficient (0.35, 1.2 and 0.7 for initial, mid-season and late season stage, respectively. The average daily pan evaporation (Ep) values from Bader Meteorological Station were used to calculate ETo as follow

ETo= Ep *Kp

Where:

ETo = Reference evapotranspiration (mm/day)

Ep =pan evaporation Bader Station

Kp = Pan coefficient (equal = 0.7)

Plants were cultivated in a following layout: object irrigated during a whole cultivation period 100% ET_o applied water (280 L/m^2), irrigated during vegetative growth till setting fruitlets100% ET_o and 80% ET_o irrigated during yielding applied water (245 L/m^2) , 80% ET_o irrigated during a whole vegetative period and irrigated 100% ET_o during yielding from the phase of fruits setting applied water (250 L/m^2) and80% ET_o irrigated during a whole vegetative period and irrigated 80% ET_o during yielding from the phase of fruits setting applied water(224 L/m^2) . The seedlings were planted into the ground in the second decade of Jun . In order to produce seedlings for 15th of May the seeds were sown in the multi-pots filled with peat substrate (cubic content of single pot was 90 cm3).In *the cultivation there was a drip irrigation used with drip line with efficiency with* emitters of 4. 0 l · h-1. The date of irrigation every 3 days, it was 20–22 irrigation doses depending of years. Plants were cultivated on a loess soil (. On the basis of results the contents of macro nutrients were supplemented to the level of: 130 mg N · dm-3 (N-NO3),32 mg P · dm-3, 150 mg K · dm-3, 45 mg Mg · dm-3. Doses of mineral fertilization were used before planting seedlings into the field with the use of triple superphosphate, potassium sulphate, ammonium saltpeter and magnesite. During vegetation plants were fertilized twice with lime saltpeter in fourth and eighth week after planting of seedlings. Harvests of fruits were done successively as they grown. It was assumed that fruits 12–17 cm long constitute yield. Dates of first and last harvests were noted and the yield and number of fruits per plant were estimated. The water use efficiency (WUE) was calculated according to FAO (1982) as follows: The ratio of crop yield (y) to the total amount of irrigation water use in the field for the growth season (IR), WUE (Kg/m3) = Y(kg)/IR (m3). Statistical analysis of obtained results was done with the use of non-parametric Kruskal-Wallis test ($p < 0.05$) with the use of SAS software (version 9.1).

RESULTS AND DISCUSSION

The effect of Zucchini plants irrigation during different growth phases on the yield, number of fruits per plant, Days to flowering, Days to first harvest and Plant fresh weight in the climate of Egypt definitely were Depending on the air temperature in the years of cultivation different reactions of plants were observed. During intensive vegetative growth of Zucchini in the year 2016 temperatures were much higher than many years mean (especially in June – by 1.5°C, July – by 1.8°C and August – by 2.1°C. is shown in (Fig. 1 and 2) and Table(1, 2, 3 and 4). The results indicated that the number of fruit and yield function of fresh weight (Fig 3,4 and 5) , Significantly higher an average yield of fruits was Obtained when plants were irrigated 100% ET_o during a whole cultivation (T_1) gave an

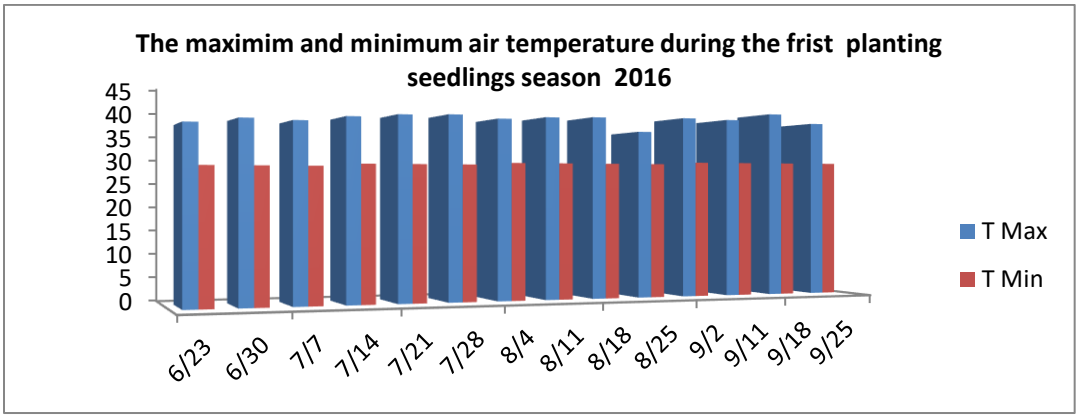

Figure 1: The maximum and minimum air temperature during the first planting seedlings

Average yield of fruits was obtained (48.1 ton. ha-1) with water use efficiency (WUE) 18.15 Kg/m^3. Irrigated during vegetative growth till setting fruitlets100% ET_o and 80 % ET_o irrigated during yielding (T_2) gave an average yield of fruits was obtained (45 ton · ha-1) with WUE 19.42 Kg/m^3. Irrigated 80% ET_o during a whole vegetative period and irrigated 100% ET_o during yielding from the phase of fruits setting (T_3) gave an

Average yield of fruits was obtained (mean 41.5 ton · ha-1) with WUE.16.09Kg/m^3. Significantly smaller yield was obtained from plants when irrigation 80% ET_o during a whole cultivation was preceded by water stress (T_4) gave an average yield of fruits was obtained (36.8 ton · ha-1) with WUE 17.38 Kg/m^3 (Fig. 4, 5 and 6)

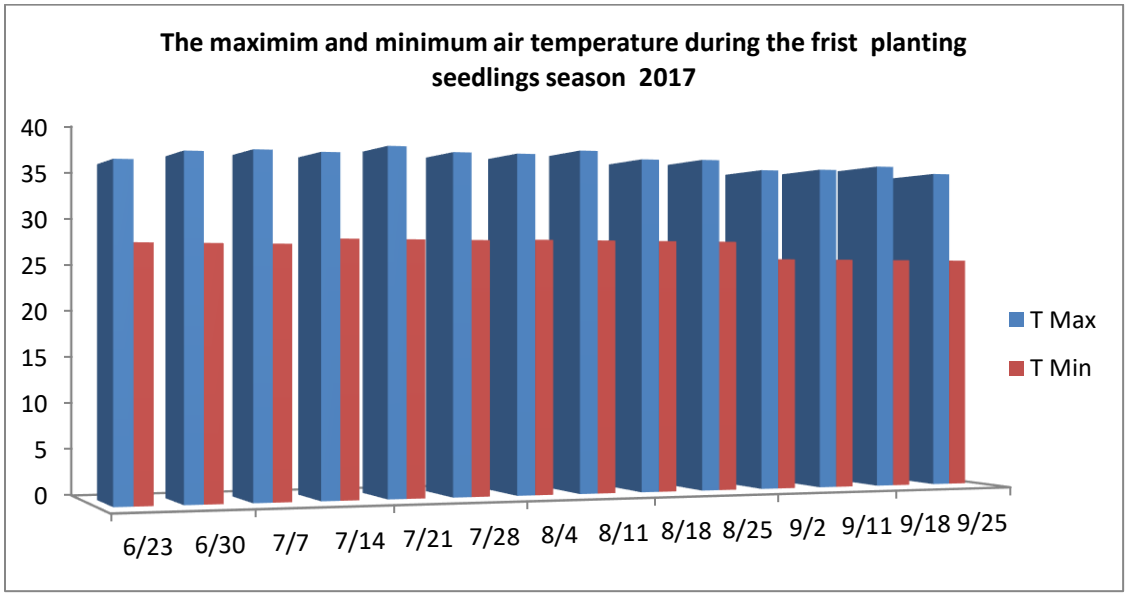

Figure 2: The maximum and minimum air temperature during the first planting seedlings season 2017

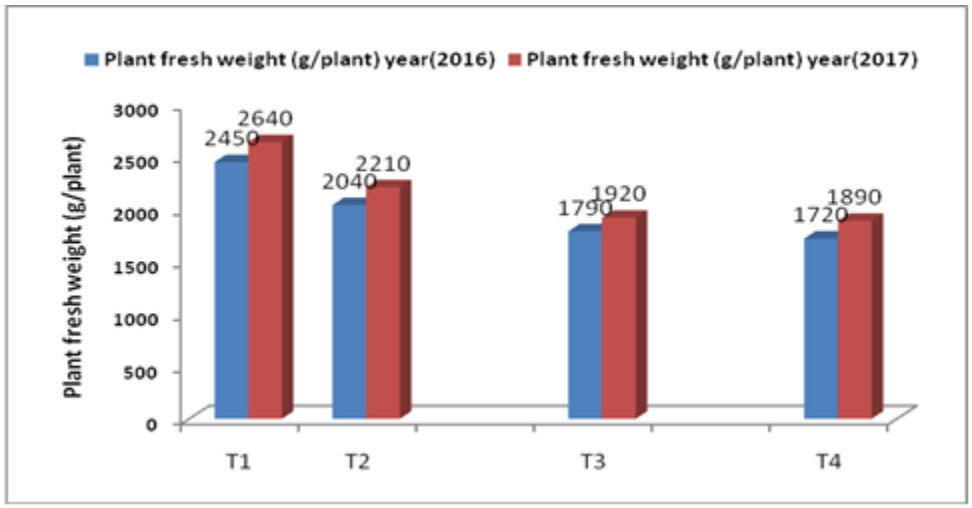

Figure 3: The effect of irrigation on fresh weight per plant

Table 1: The effect of irrigation on Number of fruits per plant

Treatments	Number of fruits per plant	
	year(2016)	year(2017)
Whole cultivation period 100% ET_o water applied 280 L/m^2(T1)	22A	24A
Irrigated till setting fruitlets100% ET_o water applied 245 L/m^2(T2)	21A	23AB
Irrigated till setting fruitlets 80% ET_o water applied 250 L/m^2(T3)	19B	22B
Whole cultivation period80% ET_o water applied 224 L/m^2(T4)	17C	21B

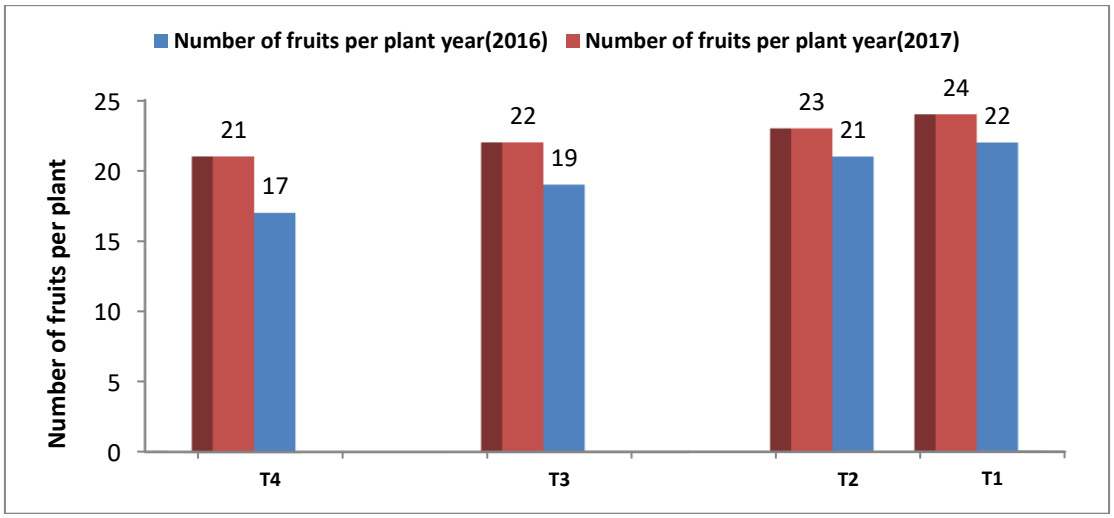

Figure 4: The effect of irrigation on Number of fruits per plant

The optimal amount of water during vegetative growth of plants, till phase of setting fruits, provided higher yield in comparison to irrigating 80% ET_o during a whole cultivation season.

The effect of irrigation on Number of fruits per plant were similar both in option with optimal soil humidity and with drought stress at the beginning of cultivation. In earlier works of Wien *et al.* [2004] it was observed that when the water shortage lasts longer the reactions occur in plants which cause decrease of osmotic potential of root cells leading to reduction of water potential of these cells enabling water assimilation .In the years 2016 and 2017higher yield of fruits was ensured with optimal plants irrigation during a whole Zucchini cultivation period. Yield of Zucchini fruits from irrigated plants were higher in comparison to other cultivation variants: irrigated and not irrigated by 2.9, 9.1 and 13.4 ton ha-1 respectively for irrigated during vegetative growth till setting fruitlets100% ET_o and 80% ET_o irrigated during yielding, 80% ET_o irrigated during a whole vegetative period and irrigated 100% ET_o during yielding from the phase of fruits setting and when irrigation 80% ET_o during a whole cultivation in the year 2016 and 2017. According to Loy [2004] in the conditions of stress water and high temperatures Zucchini plants do not develop well and the yield obtained is smaller and of lower quality. Differentiated humidity conditions in the years of research had influence on the number of fruits formed on plants and yield per ha (Table. 2)

Table 2: The effect of irrigation on yield of Zucchini fruits

Treatments	Yield Ton/ha	
	Year (2016)	Year (2017)
Whole cultivation period 100% ET_o water applied 280 L/m^2(T1)	45.5A	50.6A
Irrigated till setting fruitlets100% ET_o water applied 245 L/m^2(T2)	42.2B	47.7B
Irrigated till setting fruitlets 80% ET_o water applied 250 L/m^2(T3)	38.0C	41.5C
Whole cultivation period80% ET_o water applied 224 L/m^2(T4)	36.4C	37.2D

Table 3: The effect of irrigation on Days to flowering of squash

Treatments	Days to flowering	
	Year (2016)	Year (2017)
Whole cultivation period 100% ETo water applied 280 L/m2(T1)	21B	20B
Irrigated till setting fruitlets100% ETo water applied 245 L/m2(T2)	22B	19B
Irrigated till setting fruitlets 80% ETo water applied 250 L/m2(T3)	25A	22A
Whole cultivation period80% ETo water applied 224 L/m2(T4)	25A	23A

In the years 2016–2017, of high air temperature, plants irrigated in the early period of cultivation formed more fruits. Both in the year 2016 and 2017 less fruits (mean 19 per plant) formed plants which were Whole cultivation period80% ETo. Plants which were 80% ET_o irrigated during a whole vegetative period and irrigated 100% ET_o during yielding from the phase of fruits setting formed in the year 2016-2017 on average 20.5 fruits per plant and a average 23 fruits per plant and in the year 2016-2017 for whole irrigation priod 100% ET_o . There is an opinion, that in case of *Cucurbitaceae* lower soil humidity in the period from settling of seedlings till the beginning of fruits setting favours growth of roots and inhibits too lush growth of shoots what positively influences yielding [Loy 2004]. The first harvest of fruits started after 60 days from planting seedlings into the field and and 4 days shorter in the years 2016 and 2017.The harvest of fruits was spread in time because in the year 2016 the harvests of fruits were conducted 20 times and in the year 2017–22 times. The highest yield was obtained on the 8th of August in the year 2017 (after 74 days from the date of planting seedlings) and on the 16th of August in the years 2016 (81 days after planting seedlings) (Table . 3 and 4) and (Fig. 7 and 8).

In case of plants irrigated 80% ET_o during yielding, which proceeded period of drought stress, as well as harvest of fruits started later, after 81 days from the date of planting seedlings into the ground. In both variants of cultivation plants characterized with shorter yielding period, as there were 22harvests done in the year 2017 and 20 in the years 2016. Differences in course of yielding of Zucchini plants between years could result from different soil humidity levels

On the basis of our observations it can be stated that, regardless of different weather condition in the years, Zucchini plants which were cultivated in optimal conditions of soil humidity (irrigated during vegetative growth phase) started yielding 4-5 days earlier in comparison to plants irrigated 80% ET_o during that period. Intensive vegetative growth of plants irrigated from the beginning of cultivation extended harvesting period and increased the frequency of harvests. In the option 80% ET_o irrigation till the moment of fruiting worse branching, later fruits setting, shorter period of yielding and yielding spread in time were observed.

Table 4: The effect of irrigation on Days to first harvest of Zucchini

Treatments	Days to first harvest	
	Year (2016)	Year (2017)
Whole cultivation period 100% ET_o water applied 280 L/m^2(T1)	9B	8B
Irrigated till setting fruitlets100% ET_o water applied 245 L/m^2(T2)	10AB	8B
Irrigated till setting fruitlets 80% ET_o water applied 250 L/m^2(T3)	11AB	9AB
Whole cultivation period80% ET_o water applied 224 L/m^2(T4)	12A	10A

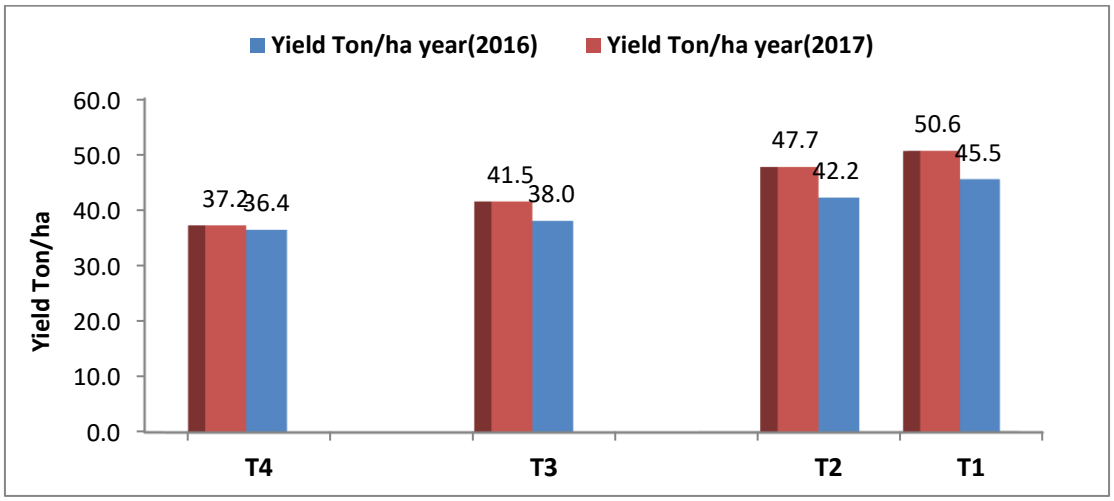

Figure 5: The effect of irrigation on yield of Zucchini fruits

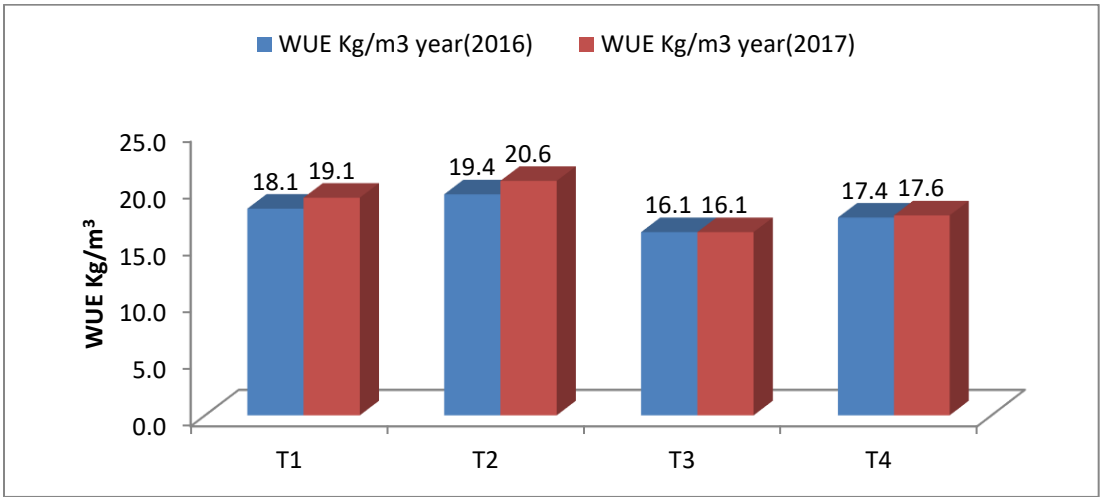

Figure 6: The effect of irrigation on WUE of Zucchini fruits

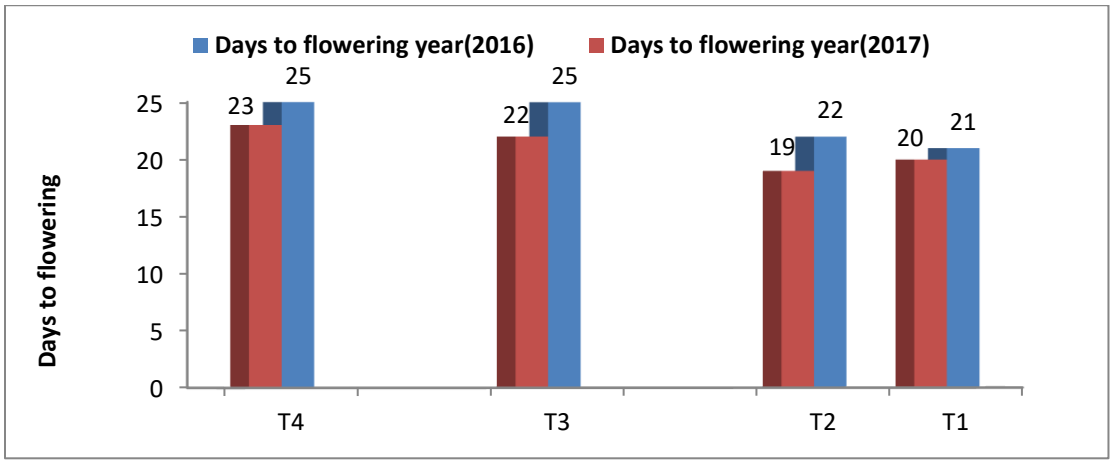

Figure 7: The effect of irrigation on Days to flowering of Zucchini

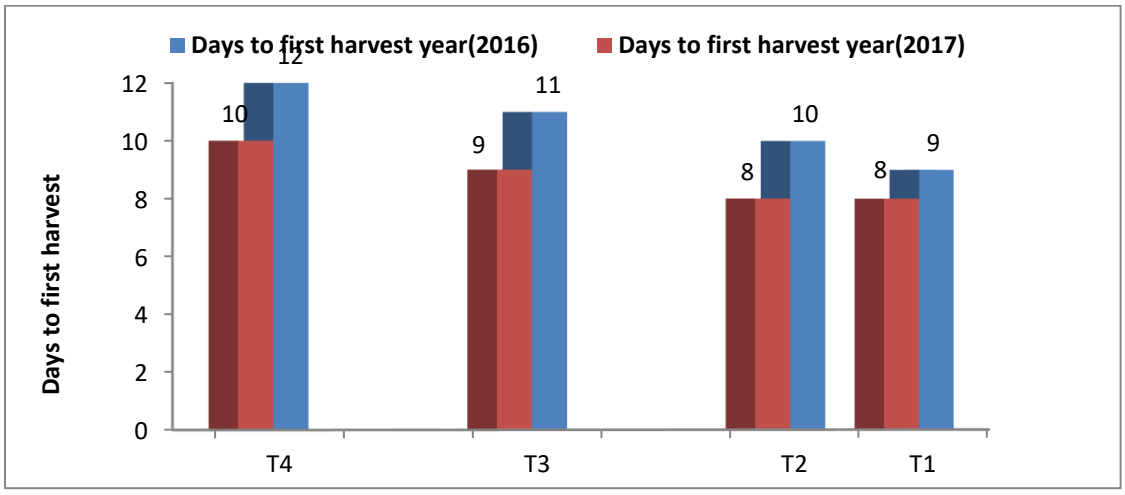

Figure 8: The effect of irrigation on Days to first harvest of squash

CONCLUSION

The efficiency of applied irrigation depended on the growth phase of plant. Plants used irrigation 100% ET_o gave whole cultivation period doses more effectively in the period from planting seedlings into field till appearing first fruitlets gave the highest yield 48.1 Ton/ha than the use irrigation 80% ET_o during a whole vegetative period and irrigated 100% ET during yielding from the phase of fruits setting gave less yield 39.8 Ton/ha . In the conditions of research there were observed bigger differentiation of Days to flowering and Days to first harvest in developmental phases of Zucchini plants. System of drip irrigation used in the whole period of Zucchini cultivation favoured earlier yielding and extending time of harvest. Use of irrigation in a whole Zucchini cultivation period and during vegetative growth of plants increased yield and number of fruits per plant.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Elsawy, A.M.[1] and Ahmed Azab[2] propose the research subject, designed the experiment and write the paper. F.A Hashem [1]and Z. Y. Maharik[1] carried out the experiment with the research team, collects the filed data and help on the paper writing

H. Mehawed (professor of Filed irrigation management at AEnRI) sharing on the paper writing and review

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