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Performance of four greenhouse tomato cultivars grown in soilless culture in Souss Massa region

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ABSTRACT

A greenhouse tomato (Lycopersicon esculentum Mill.) cultivar trial was conducted at the experimental farm of Tbhirine in Souss Massa Region (AGADIR). In this study the tolerance of tomato varieties to irrigation turn in soilless culture was evaluated. Four varieties of grape tomato were being used (Colby, Delica, Granit and Pitenza). Tree irrigation turns used in this study were (T1: Normal Irrigation Turn, T2: minus -1 irrigation, T3: minus -2 irrigations) and treatments were randomly distributed according to RCBD, with three replications. Varieties were affected differently by water stress, but, in the early growth stage no significant difference was observed. After the 3rd week of trial, Colby variety provides the best agronomic parameters regarding the apex elongation and stem diameter. However, Production parameters revealed that Pitenza and Delica varieties gave more flowers per plant (134-108 Flow/Plt) for a normal irrigation scheduling and (105 Flow/Plt) in water stress conditions. In fact, water deficit improve fruit number per plant, and accelerate fruit maturity from 0 to 5 fruits /week.

Keywords: Tomato, Soilless Culture, Irrigation turn, Agronomic parameter.

INTRODUCTION

Although greenhouse horticulture occupies a small portion of agricultural land in the world, in the last decades it expanded considerably in many areas, particularly in the Mediterranean region. Greenhouse cropping systems forces growers to adopt more environment-friendly cultivation methods, such as closed soilless culture and biological control of pests and diseases [1]. Commercial production of greenhouse vegetables is one of the most intense forms of agricultural enterprises, especially when soilless culture is used [2]. Planting corps in soilless medium is represented by the term ''hydroponics'' which related to the growing of crops with their roots in a liquid medium [3]. Several civilizations have utilized soilless culture in the past. For instance, Egyptian hieroglyphic records dating back to several hundred years describe the growing of plants in water [2]. The first proposal for a commercial water culture system was made in 1929 [4]. The use of soilless culture has substantially increased during the last decade as it contributes to the intensification of horticultural production and provides high crop yields even in areas with adverse growing conditions [5]. In the soilless cultivation techniques or hydroponic growing systems usually plants are provided with best growing conditions in order to achieve optimum yield. But even under these conditions stress may occur on plants grown in soil as well as soilless, although at different extent, in shorter or longer periods, and more severe and pervasive[6]. Also, Hydroponic system will also help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition [7]. In addition, highest yield and fruit number were obtained from Soilless culture, with irrigation once a day, twice a day watering, and irrigation levels. Soluble solids of tomato fruit decreased with increasing available water. The highest WUE value of 67.5 kg rri-3 was obtained. But WUE decreased in all treatments as the amount of irrigation water increased [8]. It was reported in the litreture [9] that the annual drainage loss of water and nitrogen from open substrate culture of rose was, respectively, 2123 m^3/ha and 1477 kg ha^{-1}. Most of the recent literature indicates that there are no objective differences between quality properties of tomato fruits produced in conventional [10]. The results of our study suggest that, the grower in the arid region and Souss Massa region should move to the soilless culture for the following reasons: high productivity, control of plant nutrition, Water economy, reduction of labor requirement, control of root environment, control of root environment, and void of unsuitable soil [11]. Several materials of substrate can be used in soilless culture, in our case; we have used coconut coir that may have characteristics that make it a useful component of soil-less-media mixes. Coir has been considered to promote excellent plant growth but there are few rigorous studies that have compared it with peat moss control plants. A few years ago [12] it was found that growth of ixora coccine was significantly reduced compared to growth in a sphagnum peat moss control. Also, it was found that there were no adverse effects of coir to tomato and pepper transplants, but a subsequent study in the same lab [13]. Arenas et al have compared soilless substrate; it was found that media with more than 50% coir had reduced growth compared to peat-grown control plants [14]. They suggested that a high N immobilization by microorganisms and a high C/N ratio in the coir may have caused the reduced growth. In addition it was reported that root development of strawberry plants grown in peat moss was better than in coir but not all studies [15].

MATERIALS AND METHODS

Experimental site and plant material: The trial was performed in the "Thibirine experimental farm" where the soilless technique was adopted. The tomatoes varieties planted were: Pitenza, Colby, Delica and Granite. The cultivation system used in this trial were the soilless system, Trial was conducted by the organization of the coco peat grow bags in three different rows as shown in Figure 1**.**

Figure 1. Green house type, spaghetti irrigation system, and soilless culture used in the trial

Plant Material: The materials selected for trial were commercial grape Tomato (*Lycopersicon esculentum* Mill.). Four of grafted varieties were planted in this trial. The plants were planted starting August at 0.4x3m spacing (density of 0.83plant/m2).

Irrigation system: The irrigation was applied using simple dripper line with 40 cm spaced emitters that gave a flow of 2 l/h/emitter. In the first row normal irrigation turns like the rest of the greenhouse, where cultivated with Calvi variety. Small valves were used for the control of the number of irrigation turns, irrigation and fertilization management were made within a fertigation station throw electro-valves. Daily reference evapo-transpiration ETo was calculated using the Penmann monteith formula [16]

Irrigation frequencies: Restrictions of water supply were applied for tomato cultivation using:
T1: Control with normal irrigation following lysimeter drainage and Penmann fomula;
T2: Treatment with less of 1 irrigation turn;
T3: Treatment with less of 2 irrigations turns.

Experimental Protocol: The responses of four grape tomato varieties to irrigation deficit in soilless culture by using coco peat material were evaluated.

Experimental Design*:* Figure 2, illustrates the adopted experimental design with total randomized blocks, with tree irrigation treatments and four tomato varieties for tree repetitions.

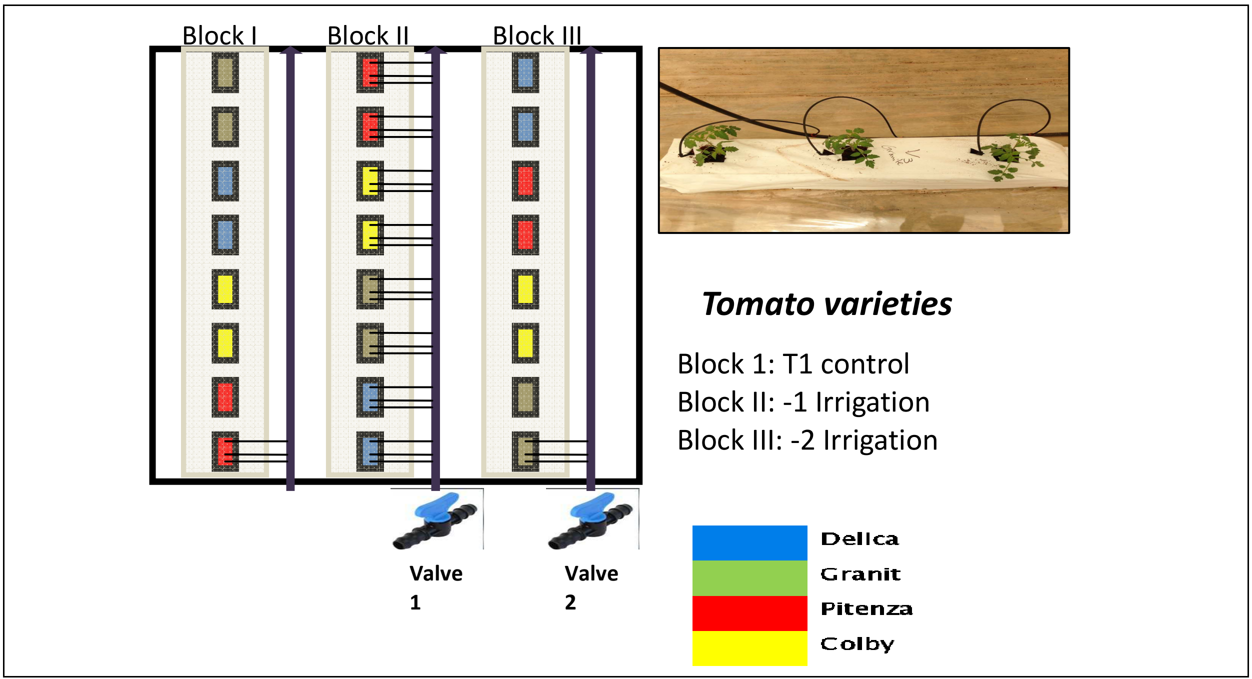

Figure 2. Organization of the trial inside the greenhouse with normal, -1, -2 irrigations turn

Fertilization management: It was decided to give a nutrition solution to all plants from the same tank. We change only the dose of each fertilizer. Then, salinity of the concentrated solution is always fixed but the amount of used fertilizers changes according to the plant requirement for each treatment. The fertilization scheduling is shown according to the different stages where the solution equilibrium was calculated. The same fertilization was used in the rest of the greenhouse. All needed nutrients were regularly supplied to the plants with correspondent irrigation and the choice of suitable nutrient solutions which were made considering the level of the nutrients in the tap water.

Measuring tools: The measuring tools used in the experiment were a complete telemetric weather station; Soil moisture probes (C-prob, Easy AG, Hydra-prob, AquaCheck); Drip sensors to control water supply; Lysimeter to estimate drainage; pH meter to measure acidity of irrigation water and drainage water; and EC meter to measure salinity in irrigation and drainage water. All measurements are automatically recorded every 15 minutes and then transmitted to a base station for computer data processing.

Measured Parameters
Climatic parameters**:** Temperature, relative humidity, radiation, wind speed and direction, rainfall and Substrate and soil moisture.

***Agronomic parameters*:** Many parameters have been controlled to monitor the vegetative growth of each treatment from the beginning of September: the apex elongation in cm, the stem Diameter in mm at 20 cm from the apex, the length (cm) between internodes, the number of flowers (tot/plant), the number of fruits (tot/plant) and the number of harvested fruit. For all the trial measurements were taken on a weekly basis.

***Statistical analysis*:** All data were analyzed by student test, and value of $p < 0.05$ were considered to be significantly different**.**

RESULTS AND DISCUSSION

As shown in figure 3, a decline for all the tested varieties at normal, (-1) and (-2) irrigation is shown at week 3, this reduction could be due the pH of the nutrient solutions which in turn influenced the uptake of nutrients which affected the elongation apex.

After the 3rd week, remarkable increase of elongation was observed. In particular, normal and (-1) irrigation. It appears that tested varieties are affected by irrigation turns, this effect can be observed in T1 (19% between strong and weak variety), and can be serious with T2 (37% between strong and weak variety).

Under the evaluated irrigation conditions Colby appear the most stronger and more tolerant with effective elongation between 3 and 5cm/week.

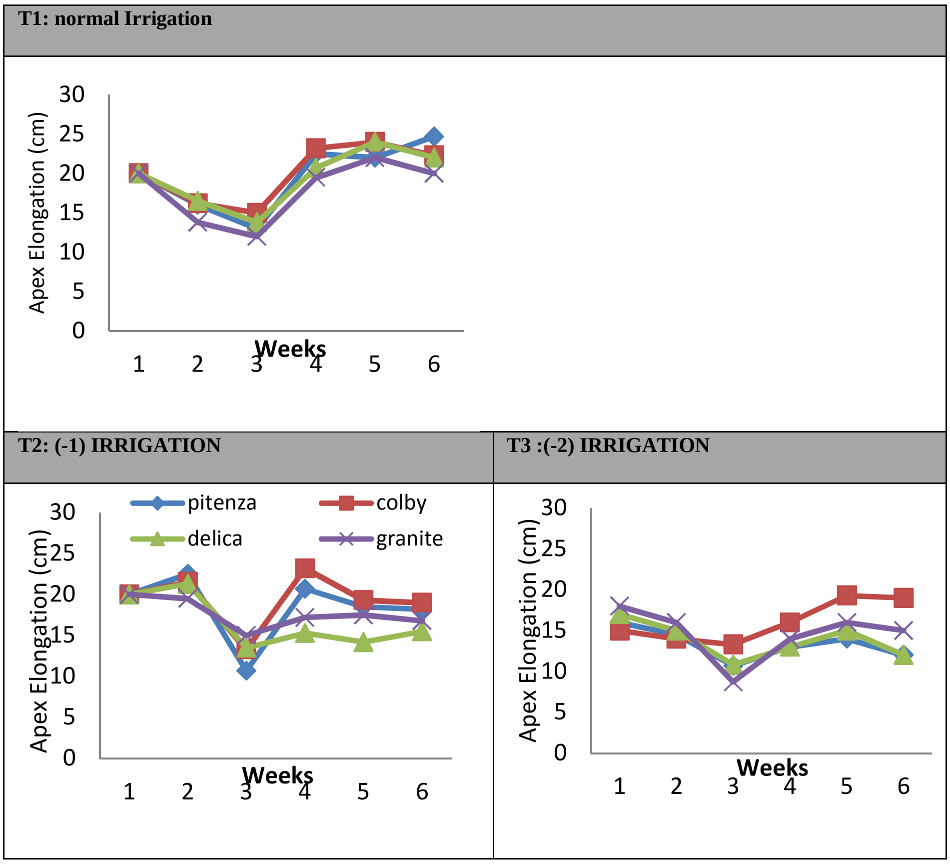

Figure 3. Apex Elongation in cm of Pitenza, Colby, Delica and Granite at T1, T2 and T3 for 6 weeks

Stem Diameter: The effect of various type of irrigation on stem diameter was also evaluated. Results of 6 weeks measurements are summarized in Figure 4**.** Statistical analysis of results shown in Figure 4

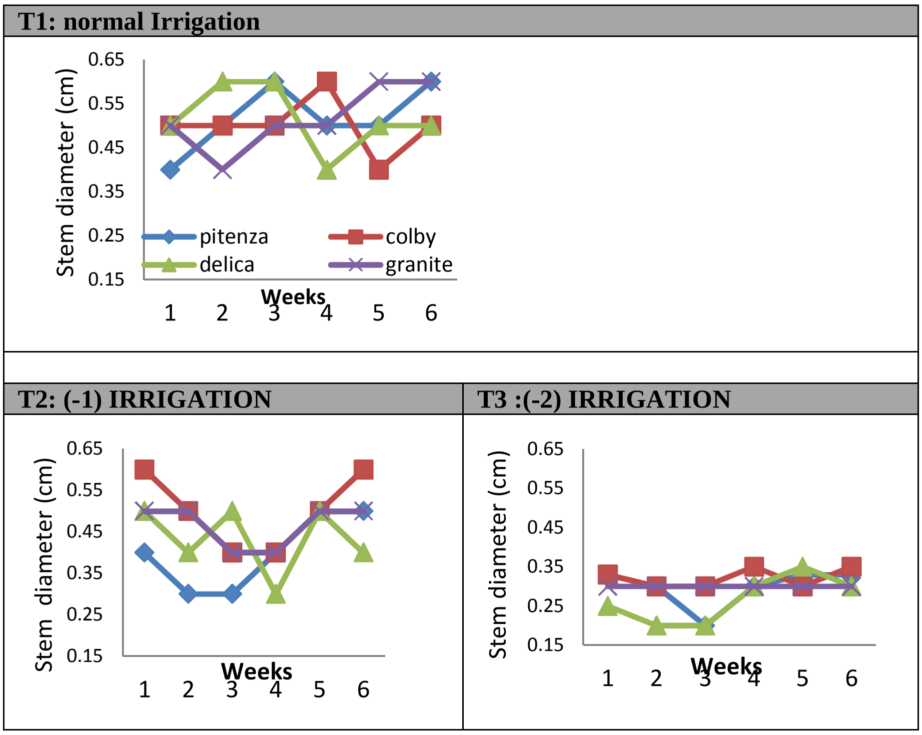

Figure 4. Effect of irrigation turn on Stem diameter of Pitenza, Colby, Delica and Granite at T1, T2 and T3

It shows significant differences in the stem diameter's between studied varieties at normal T1 and T2: (-1) irrigation turn. In fact, all studied showed that, tomato varieties are sensitive to decrease in irrigation turns, this sensitivity is expressed by reduction of stem diameter. At normal irrigation stem diameter were between 0.4 and 0.6 cm for all varieties which is the highest. This could be related to the normal nutrient solution utilized in this case [16-18]. However, for the case of strong deficit irrigation frequency T3, no significant deference in the stem diameter was observed and after the 3rd week, and all varieties expressed a stable stem diameter. In normal irrigation conditions "Pitenza" and "Granit" varieties seem to give the strong stem diameter.

Internodes Length: The effect of the irrigation on internodes length was also evaluated. Statistical analysis of the results showed a significant effect of irrigation turns on internodes length (figure 5). The results summarized in figure 5 presents the average length of internodes for each treatment and show significant differences between treatments. By analysing the results in Figure 5, we could conclude that, the length of the internodes is differently affected by irrigation frequency. In fact, in normal irrigation conditions (T1) "Pitenza" variety seem to haves the larger internodes and all varieties are show an increase in the internodes length after the 3 week of trial and reached about 20-23 cm at the 6th week.

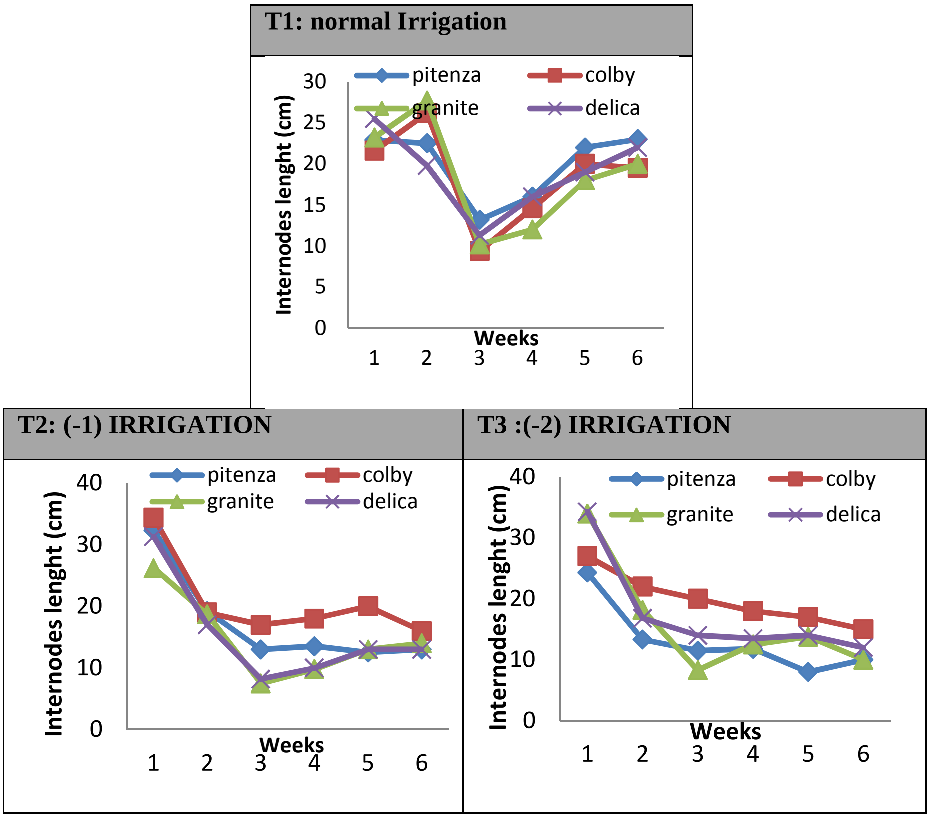

Figure 5. Internodes length of Pitenza, Colby, Delica and Granite at normal, (-1) and (-2) irrigation as a function of time

For a stress conditions (T2 and T3) stem diameter seem to be constant with a small decline in agreement with[17] due to irrigation deficit, the value of internodes length at the 6th week was between (13-16cm) for T2 and (12-15cm) for T3.

Effect of irrigation frequency on tomato production

Effect of irrigation turn in tomato flowering: To evaluate the effect of irrigation turns in fruit production two parameters were studied: Flower number and harvested fruit for each variety and treatment. Results of flower computation for sex week of observation are summarized in figure 6.

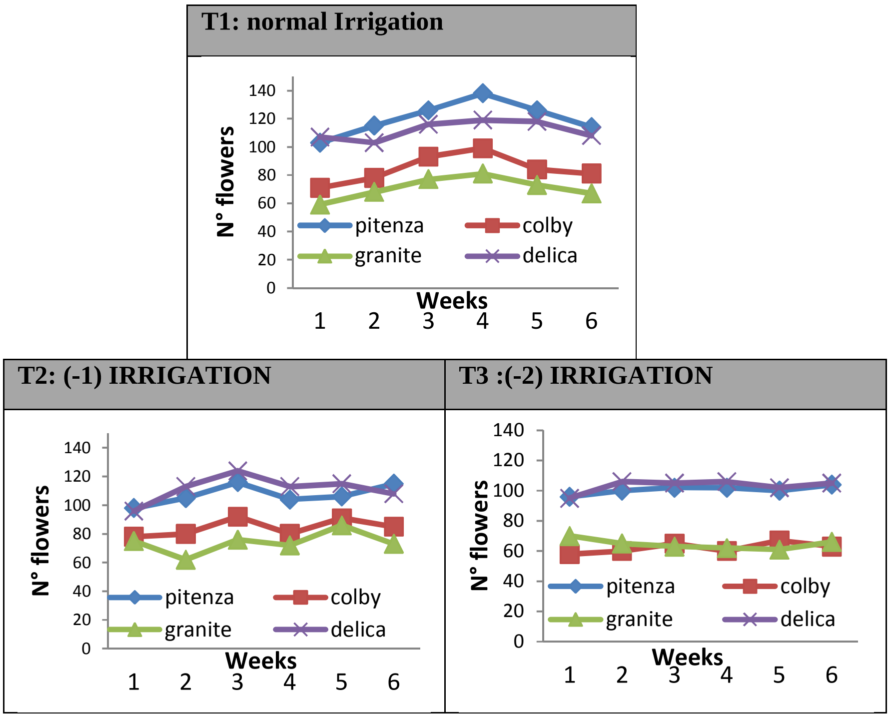

Figure 6. Number of flowers of Pitenza, Colby, Delica and Granite at T1, T2 and T3 as a function of time

According to the analysis of results shown in Figure 4, the number of flowers in all irrigation turns (T1, T2, T3) revealed that it can be separated to homogeneous group of varieties: Group limited flowers (Colby and Granit) and group with more flowers (Pitenza and Delica).

Irrigation frequency decrease slightly the number of flower (138 Flw/Plant, 124 Flw/plant and 106 Flw/Plant) for (T1, T2 and T3), respectively. It was also observed when irrigation turns e decreased less flower number were lower[17] in the case of T3.

Effect of irrigation turn in fruit production: The effect of the irrigation turn on tomato production and performance was studied on all varieties. Produced fruits by week are computed and reported in figure 7.

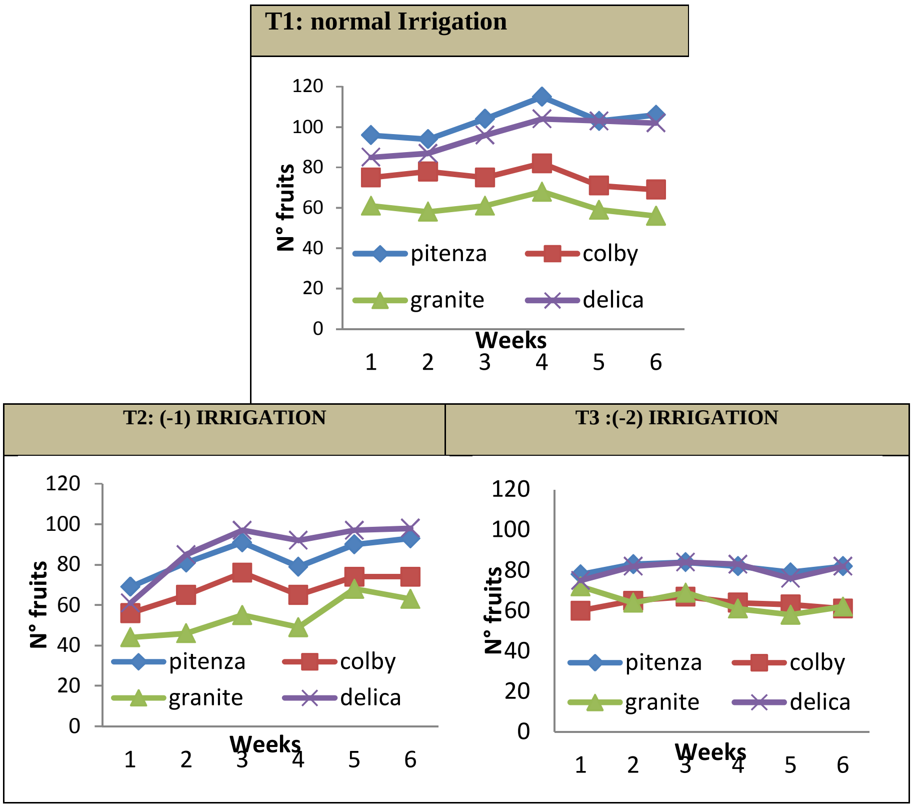

Figure 7. Effect of irrigation turn in fruit production

From Figure 7, it could be conclude that the varieties Delica and Pitenza showed better performance. The results also show that, number of fruits given by all varieties is not stable over the time. The figure show that, at normal irrigation, produced fruit fluctuates between 85 and 110, however, at (-1) irrigation fruit production changes between 65 and 100 and at (-2) irrigation range between 78 and 85 fruits.

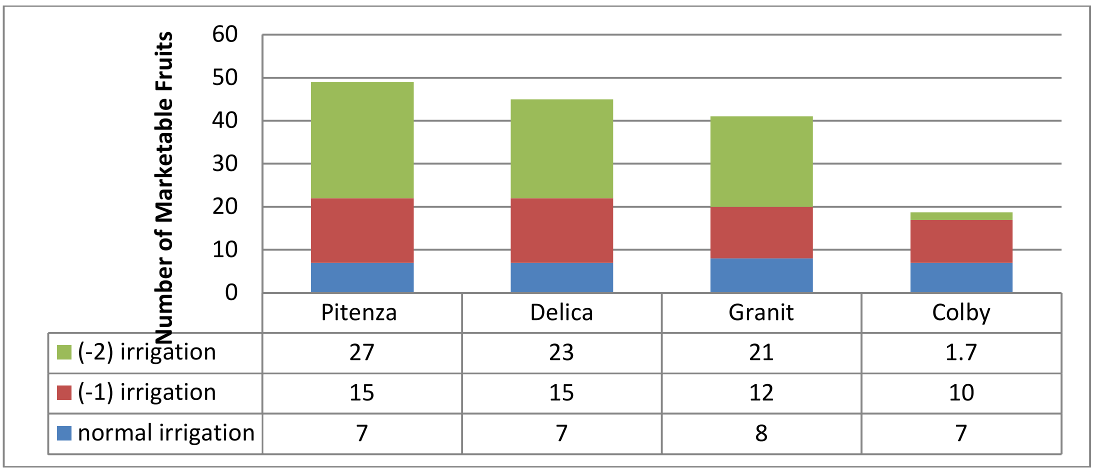

Figure 8. Effect of irrigation turn on marketable fruits for Pitenza, Colby, Delica and Granite at normal, (-1) and (-2) irrigation over the time

Statistical analysis shows that irrigation frequency affects significantly tomato fruit production. The reduction in fruit production is more clear in T2 to T3 (98 fruit/plant, 74Fruit/plant) for Delica variety. It was noticed that, water deficit reduces the production of fruits and difference between varieties performances.

Effect of irrigation turn on fruit harvesting: To understand to effect of irrigation frequency on marketable fruits of grape tomato, six harvests have been measured and compared. In a 6 weeks trial the total number of harvested fruit has been accumulated for each variety and each treatment. The results of this operation are reported in the figure 8.

The results summarized in Figure 8 showed that, the number of marketable fruits is significantly affect by irrigation turn, the lesser the number of the irrigation the higher the number of marketable fruits for all the studied varieties. By the way, at (-2) irrigation the number of fruits harvested in all the varieties is higher than the number of fruits discarded at (-1) and normal irrigation. In addition, it can be seen that the variety with the highest numbers of marketable fruits was “Pitenza” while the variety with the lowest number of harvested fruits was Colby. However, Irrigation sowed a greater effect on the average fruit weight than on fruit number [19]. These results are good for farmers who produce cluster tomato, when we look for more clusters and more fruits and not for a big calibre of fruits.

CONCLUSION

The trial showed that, the irrigation frequency in soilless culture affect considerably and differently the physiological parameters of tomato cultivars. In fact, water stress as decreasing irrigation turn can slow down the plant growth, by reducing elongation of internodes, stem diameter, and number of flowers per plant. However, reducing irrigation turn can improve maturity of fruits and give more marketable fruits. The results suggest that, for all tomato varieties that are used in this trial, the best results could be attained by first starting with normal irrigation for early stage of plant, and then reduce irrigations turns in the stage of fruits harvesting to accelerate maturity and increase number of marketable fruits.

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