Full and deficit irrigation of "Mountain Tea" plant, at low altitude (first growing season)

Gıouvanıs V.[1,*], Sklavounos K.[1], Avlogıarıs I.[1], Papanıkolaou C.[1], Wogıatzı E.[2] And Sakellarıou – Makrantonakı M.[1]

[1] University of Thessaly, Department of Agriculture, Crop Production and Rural Environment, Volos, Greece

[2]Technological Education Institute of Larissa, Department of Plant Production, larissa, Greece

*corresponding author:Giouvanis Vasileios

e-mail: vgıouvanıs@uth.gr

Abstract. The aim of this research is to study the effects of full and deficit irrigation regarding to the growing, productive and qualitative characteristics of "Mountain Tea" plant (Sideritis raeseri). The surface drip irrigation system was used. The research took place during 2015 at the experimental field of the University of Thessaly, in Velestino, Magnisia, Central Greece. It was used a fully randomized compete block design with two treatments in three replications. The amount of supplied water was 50% and 100% of the water needs according to the daily evapotranspiration (ETc) using the method of Penman-Monteith FAO 56. The plant height, the fresh and dry biomass production were measured and the crop's qualitative features were analyzed. The results shown that "Mountain Tea" can be cultivated at low altitude using irrigation. Moreover there are no statistically significant differences ($P<0.05$) of the growing and productive characteristics between full and deficit irrigation treatments. As for the studied qualitative properties, the results showed that the deficit treatment surpass compared to the full one. Thus, deficit irrigation is at least as productive as the full one, having the same effects on tea quality while an important amount of water can be saved as well.

Keywords: Mountain Tea, Surface Drip Irrigation, Deficit Irrigation, Water Saving, Low Altitude.

1. Introduction

In countries with limited water resources, where the irrigation demands are higher than 70% of the water use and the competition about it with other economic sectors will be higher and higher especially if the demand for fresh water increases even more and the quality of that natural resource downgraded (Fereres and Evans, 2006, Sakellariou *et al*., 2008).

The limited condition of the water resources around the Mediterranean area and the population increase demands the Water Use Efficiency (WUE) to be improved, imperatively (Katerji *et al*., 2008). A report of the European Union in 2012 about investigating measures to increase water saving claimed that improving water use efficiency could save 15 to 60% of the total water use (Mudgal *et al*., 2012). Other researches, in Greece, showed that the optimum irrigation scheduling in comparison with the deficit irrigation improve the water use efficiency (Sakellariou and Papanikolaou, 2008).

Under the frame of an optimum management of the water demands, the irrigation programming is the key point. It is crucial to decide when and how much water do the farmers have to use. A number of different factors such as the development stage of the crops and their differences in sensitivity to the irrigation limitations as well as the different climatic conditions and the water availability determine the irrigation interval. However, the irrigation interval differs according to the irrigation method and under that point of view irrigation programming and irrigation methods are close related to each other (Chartzoulakis and Bertaki, 2015; ICID/FAO, 1995).

The aromatic and pharmaceutic plants possess a high position in the culture of the most civilizations through the centuries. The "Mountain Tea", specie of the Greek flora, is part of a series of aromatic plants and herbs that are famous for their pharmaceutical properties as well as their byproducts and their essential oils (Koedam, 1986).

The species of Sideritis raeseri are native ones in Mediterranean and the round areas at a height upper than 700m and especially in Greece (Goliaris, 1984). The Greeks used that specie and it is well known under the names of "Greek Tea" or "Mountain Tea". The Greek producers, at their fields, try to simulate the physical development conditions of tea in order not to downgrade its quality. However, there are cultivated fields with tea in lower altitudes, such as 100m where is produced as qualitative tea as in the mountains. Tea reproduced through offshoots and the new plants are planted directly to the new position. Suitable soils are the moderate mountainous limestone soils and the well-plowed and the well-drained ones. The harvesting usually takes place in July, when the plants are in full bloom. Afterwards the harvested quantity dries. The dried product is packaged in bales, covered with sackcloth, and in this form is stored in well-ventilated warehouses until the sale (Gabrieli and Kokkalou, 1990).

The cultivation technique is improving up today, continually. Nevertheless, some basic cultivation issues such as herbicide, harvesting, fertilization and drying are

still under discussion. The irrigation effect is under study, too (Sklavounos, 2016).

Taking those into consideration, the current research studies the effect of full and deficit irrigation on the "Mountain Tea" crop in low altitude. The aim of the study is to conclude in irrigation practices which are going to optimize the irrigation water use in the "Mountain Tea" crop and the possibility the development, the productivity and the qualitative characteristics of the tea plant to be affected.

2. Materials and Methods

The research took place during the cultivation period of 2015 at the experimental farm of the University of Thessaly in Velestino area. It was studied the development and productivity of the plant "Mountain Tea" under deficit irrigation conditions (1st cultivation period). The Velestino area is placed at the west site of Volos and the Latitude is 39° 23' North while the Longitude is 22° 45' East. The altitude is 50m above the sea. Each of the experimental fields were 0.05 hectares. The climate of the area characterized as typical Mediterranean and continental with hot and dry Summer followed by a humid and cool Winter. The soil characterized as clay loam with high amount of calcium and good drainage. Generally, the texture of such soils is normally characterized as sandy clay loam to clay. The soil particle is moderate-grain to fine-grain. Its pH is high in the area of alkaline soils and its porosity is well developed with small and moderate pores in size (Mitsios *et al*., 2000, Terzidis and Papazafeiriou, 1997).

The cultivation technics was done during the March of 2015. A heavy cultivator was used as first and it was followed by a light milling some days later so as the soil to get in the right condition to be plant. The tea plant was planted at 24 of March 2015. According to the climatic conditions of the area and the physiology of the crop, the planting is characterized as late season. It was used a Randomized Complete Block design with four treatments in three replications. In each replication, six small furrows, four to five centimeters deep was dug by hand. The furrows equidistanted each other exactly 50 cm. The tea plants were planted by hand with 50cm distance apart and 50 cm distance between the rows. No fertilization was followed the planting. At 21st of April the irrigation system was placed. It was used surface drip irrigation system. The FAO Penman – Monteith method was used to calculate the daily evapotranspiration ETo (FAO, 2011, Panagiotou, 2016).

The measurements of the plant characteristics were done in the two of the total four treatments (full research). Analytically, it was measured plants from the treatment that covered the 100% of the crop water needs and from the treatment that covered the 50% of the crop water needs. It was measured the plant height, the fresh and dry biomass and analyzed some qualitative characteristics of the plant. The results were analyzed statistically.

The plant height is a general plant characteristic through which the plant growth rate can be measured. Taking that into consideration a sample of 10 plants was selected randomly in each replication so as to the height to be measured. The mean plant height of each treatment was the mean plant height of the 10 plants from each replication.

The harvest took place at 26 of June 2015 and the sampled plants weighted in a high accuracy scale. Those cut plants were baling and placed in a closed, shady greenhouse with opening windows for 10 days so as to be dried, physically. After the 10 days the dried plants weighted in a high accuracy scale.

The analysis of the qualitative characteristics of the plant followed a specific protocol. The leaves, flowers and steams were fully mixed. Three grams of that mixture were taken and dissolved in 100ml of boiled distilled water for 10min. The extract was taken through infiltration. It must be noted that the 3g is a dose of tea and the 100ml of boiled water is equal to a cup of tea while the 10 min is as much time as it is needed for a cup of tea to be prepared so as to get drunk. The total phenols expressed as equivalent to the France acid and it was used the Folin reagent. The antioxidant capacity expressed as equivalent to Trolox and it was used the FRAP method. The whole procedure took place at the University of Applied Sciences of Thessaly, Technological Education Institute (TEI) of Thessaly.

The statistical package SPSS v.18 was used so as the data to be analyzed. The statistical analysis was done for the total research i.e. the four treatments in three replication. Taking that into consideration, as well as that the analysis was about two mean values (one for the treatment 100% and one for the 50% one) of each of the three plant characteristics (height, fresh and dry biomass) as for one factor (the irrigation dose), the ONEWAY ANOVA was used in 0.05 level ($P<0.05$) (Montgomery and Runger, 1999).

3. Results and Discussion

3.1 Weather Data

The Graph 1 shows the mean temperature and the precipitation during the cultivation period of 2015 as well as the mean values of those climatic parameters of the last 25 years.

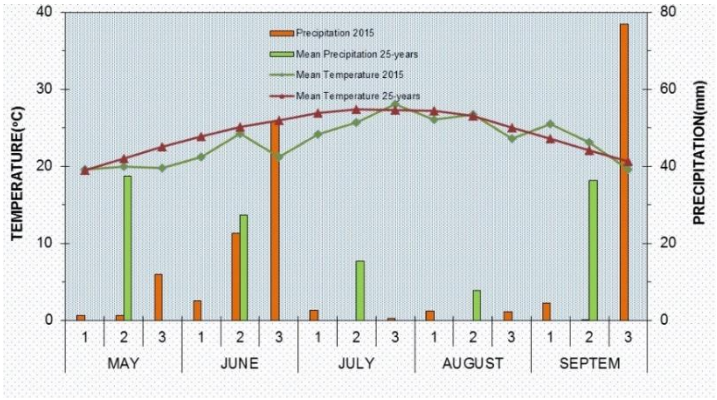

Figure 1. Mean temperature and precipitation of the year 2015 and the last 25 years.

The precipitation of 2015 was a bit out of the mean plan of the last 25 years. It is obvious that during the second 10-days of May the precipitation was almost absent in comparison with the mean values of the 25 years. The same observation was done during the second 10-days of September. However, during the third 10-days of the June and September the amount of precipitation was diametrical the opposite than the mean values of the 25 years.

The temperature values were more or less the same as the mean temperature of the last 25 years. During the third 10-days of June it was observed lower temperature than the expected. Both temperature and precipitation were in favor of the crop until the harvest period.

3.2. Plants height

The plant height measurements in the two treatments took place in 26 of June 2015 the same day when the harvesting of the cultivation was taken place. In Graph 2 it can be shown that the mean plant height in the treatment 50% measured at 33.31 cm while in the treatment 100% was 34.79cm. As it can be extracted from the statistical analysis the significance is higher than the fixed level of 0.05. So, there are no significant differences as for the mean plant height between the two treatments.

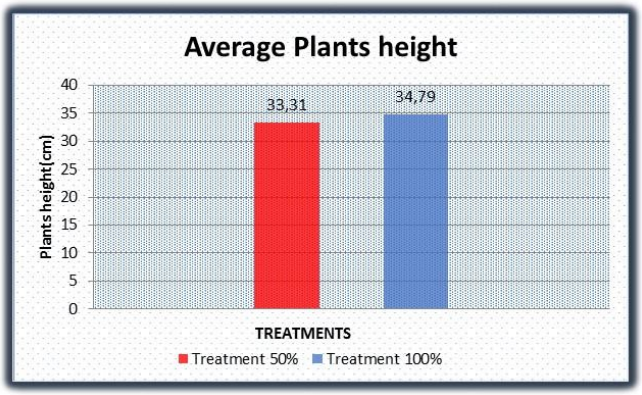

Figure 2. Average plants height of each treatment

3.3. Fresh and dry biomass production

The wet weight measurements were taken the same day when the cut of the inflorescence and the height measurement took place. The dry weight measurements were taken 10 days after the wet weight ones. As it can be seen in the Graph 3, the production per hectare of the dry matter was lower than usually. It was an expected result as the crop was in the first season as well as the planting was late out of the normal season.

In Graph 3 the total wet and dry weight of each treatment can be observed. The difference of the wet weight between the two treatments is small without any statistical difference. The treatment 50% produced 0.21 Mg/hectare while the treatment 100% 0.24Mg/hectare.

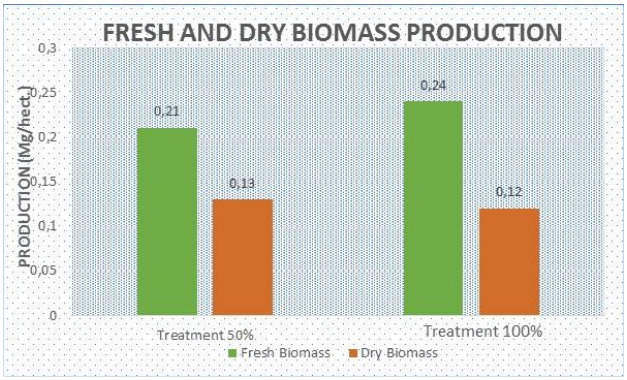

Figure 3. Fresh and Dry weight of each treatment

The same result observed as for the total dry weight between the two treatments. The difference is quite small as it was expected without any statistical difference. The treatment 50% produced 0.13Mg/hectare while the treatment 100% 0.12Mg/hectare.

It must be noticed that the total wet weight in the treatment 100% was higher than the treatment 50%. However, the total dry weight was lower than the treatment 50% i.e. the total dry weight in the treatment 50% was higher than in the treatment 100%. That "unexpected" result can be explained taking into consideration the affection of the extra amount of water among the plant tissues in the total wet weight of the full irrigated treatment in comparison with the less one in the deficit irrigated treatment.

3.4. Qualitative crop characteristics

The total phenols and the antioxidant capacity of the three replications of each of the two treatments are presented in Table 1. It can be observed that the total phenols as well as the antioxidant capacity in all the replications of the treatment 50% are quite increased in comparison with the treatment 100%. It is quite noticeable result that using deficit irrigation it could be achieved not only irrigation water saving but also higher biomass production as well as higher product quality.

Table 1. Total Phenols and Antioxidant Capacity (FRAP) of the three replications of each of the two treatments.

Samples	TP ((Total Phenols)	Andioxidant Capacity FRAP
Treatments	mg (GAE) /3 g Dry Weight	mM (TEAC)
50%	63,43	3,6
50%	65,76	3,6
50%	62,94	3,7
100%	50,54	3,3
100%	51,20	3,3
100%	51,20	3,1

4. Conclusions

A research took place during the cultivation period of 2015, at the experimental farm of the School of Agricultural Sciences of University of Thessaly in Velestino area. It was studied the development and productivity of the plant "Mountain Tea" under deficit irrigation conditions (1st cultivation period).

The "Mountain Tea" can be cultivated in low altitudes provided that irrigation is going to be used no matter if the planting is on season or late. There is no significant difference between the treatments as for the development characteristics (height) as well as the productive characteristics of the plant (dry and wet weight).

As for the qualitative characteristics of the crop that they were studied, it was observed that the total phenols and the antioxidant action were increased in the treatment 50% in comparison with the treatment 100% (≈20%).

Therefore, deficit irrigation produced the same or even higher production and saved grate amount of irrigation water.

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