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Irrigation of Young Olive Trees with Treated Waste Water

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IR2MA
Large Scale Irrigation Management Tools for Sustainable Water Management in Rural Areas and Protection of Receiving Aquatic Ecosystems

Subsidy Contract No: I1/2.3/27

Project co-funded by
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Partners

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Notes

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Irrigation of Young Olive Trees with Treated Waste Water

Involved partners:

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Introduction

Pressure on water resources and water reuse

There are two distinctive trends that pose a pressure on global water resources: increasing demands and climate change but there is only one underlying true cause for global water scarcity: capitalism expressed through the disrespectful to environment and human's health intensification of production for the maximisation of profit. In this unstable equilibrium one thing is sure: the unnegotiable right for everyone to have access to safe and abundant water. The only solution to this would be the fair water resources appropriation and communism of course.

There are two distinctive trends that pose a pressure on global water resources: over-withdrawal and global warming both expressing the effect of anthropogenic activities on the planet. Intensification of production to meet the modern consumer society's needs has a detrimental effect on planet mainly expressed through overexploitation and mistreatment of natural resources. Freshwater is implicated in most of human activities and limited access to it either due to subsequent decrease in its quantity or due to deterioration of its quality caused by pollution will undisputedly affect global economy.

Little can be done towards the increase of the quantity of available natural water resources, so protection and sustainability of the already existed is imperative and this can be ensured by water resources management through effective water use, increase in water productivity, quality monitoring, reduction of pollutants' disposal, recycling and reuse.

Water reuse refers to the reclamation of water, that otherwise would be discharged to the environment, from several sources and the subsequent treatment (in municipal wastewater treatment plants) before use. These sources include: municipal wastewater, water derived from industry or other processes (such as natural resource extraction activities), cooling water, rain or storm water, agriculture runoff and return flows. The reuse after treatment potentials refer to: non-potable uses such as irrigation or domestic reuse, indirect potable uses which include the additional treatment with an environmental buffer (lake, river or underground aquifer) before drinking and the direct potable uses where additional environmental treatment is not included.

The idea of water reuse has been employed from ancient years (Singh 2021) but during the last decades more organized schemes have been applied. These schemes demand in the first place the advanced treatment of waste water, the safe storage and the safe transfer through a separate pipe network to the reuse points in order to ensure the conformation to the hygiene standards of each region and each use. Safety standards refer to either chemical and heavy metal contaminants or microbial load which are hazardous for the environment and human health.

The adoption of wastewater reuse practice advances with a slow pace mainly due to the large investments that are required and the low public acceptance. Globally and in European level there is a lack of data regarding waste water treatment and reuse (Sato , et al. 2013). Almost 1 billion m^3 of treated wastewater in Europe is reused annually accounting for the 2,4% of the treated urban wastewater effluents. If we take into account that this comprises the 0,5% of the total annual fresh water withdrawals in the European Union, we can understand that the EU's potential of water reuse is much higher (Kirhensteine, et al. 2016).

Although many countries have developed the legal basis for water reuse, the lack of a common legislative framework burdens the further adoption since it complicates international trade. The 2000 and 2008 EU directives set the standards for priority pollutants such as pesticides, PAHs, phenolic compounds and volatile organic compounds but quality requirements for pathogenic contamination and microorganic pollution were not included. The 2020 Directive on Minimum Quality Requirements for Treated Waste Water Reuse which will be in force in 2023 is expected to accelerate the uptake of water reuse practices.

Agriculture continues to be the largest withdrawal and consumer as the 70% of the world's fresh water being used for irrigation and this underlines the potential of water reuse in this sector. Globally agricultural irrigation is the main application of water reuse with a share of 32%, industry follows with a share of 19,32% while ground water recharge represents only the 2,17% of the total global reuse. In EU withdrawal of fresh water for irrigation purposes accounts for the 36% of the total 182 billion m^3 of freshwater abstracted per year (Kirhensteine, et al. 2016).

The Sustainable Development Goal 6 (SDG 6), the goal of ensuring water and sanitation for all by 2030 has set the baseline and the special targets for water reuse (UN-Water 2021). Although in the EU many initiatives have taken place the last decade towards wastewater reuse only Cyprus and Malta present a high uptake of this practice having managed to reuse the 89% and the 60% respectively of their wastewater. In Greece, Italy and Spain the uptake rates range between 8-12% (Pistocchi, et al. 2017).

Waste water reuse projects in Greece – a review

At present, the 88% of the population in Greece is connected to urban waste water treatment plants (WWTP) as a result of the country's alignment to the relevant European Union's Directives (91/271/EEC and 98/15/EEC) (E.C. 1991) (E.C. 1998). This is one of the highest scores in the EU compared to the 80% mean value of the northern EU countries and the global 59%. The reclaimed water reuse for agricultural irrigation is practiced in only 13% of the existing wastewater treatment plants in Greece. It is estimated that almost 18.000 ha are being irrigated by the several agricultural water reuse projects in Greece, whereas almost 60.000 more ha are irrigated via the indirect wastewater reuse (Ilias, Panoras and Angelakis 2014) (Prochaska and Zouboulis 2020). Indirect waste water reuse refers to the disposal of treated waste water in rivers and the uptake of the mixed water for irrigation.

There are several projects of treated wastewater reuse in operation mainly for agricultural irrigation and secondarily for landscape irrigation, fire protection etc (Prochaska and Zouboulis 2020) (Ilias, Panoras and Angelakis 2014). The major project is the one in Thessaloniki which produces 165.000 m^3/day secondary effluent. The effluent is mixed with freshwater from the Axios river at a ratio of 1:5 and 2.500 ha of spring crops in the adjacent plain are irrigated with the mixture. Smaller wastewater reuse projects are also in operation around the country. In Crete the WWTP in Hersonissos provides 4.500 m^3/day of treated waste water used mainly for agricultural irrigation and secondarily for fire protection and landscape irrigation and a second WWTP at Malia which provides 2.500 m^3/day of treated effluent mainly for irrigation purposes. Recently (since 2012) a new water reuse project has been in operation in the city of Iraklion where 9.500 m^3/ha effluent of a tertiary treatment plant which includes coagulation, filtration, and UV disinfection, is used for grape and olive tree irrigation, in the southwestern area of the city. Other small projects are in operation at Levadia (3.500 m^3/day), the island of Kos (3.500 m^3/day), Amfissa (400 m^3/day) and at Nea Kalikratia (800 m^3/day). In Chalkida the effluent of the local WWTP is used since 1998 for landscape irrigation. Regarding the cases of indirect use, there are some small projects especially in central Greece (Larissa, Trikala, Karditsa, Lamia, and Tripolis) and cover the needs of the respective adjacent plains (Prochaska and Zouboulis 2020).

Transportation expenses are the main obstacle to the wider adaption of the wastewater reuse application in agriculture in Greece. Most WWTPs are situated quite far away from arable agricultural land. This increases the transportation costs posing another economical challenge. This is the case of the WWTP of Athens which serves almost the half population of Greece (5 million) and is located on the Psytalia island in the Saronikos Gulf, far from the inland plains. Part of its effluent is reused only onsite as process water for treatment (Prochaska and Zouboulis 2020).

The total irrigated land in Greece reaches almost the 103.860.000 ha/year (Prochaska and Zouboulis 2020) and the country's Mediterranean climate requires additional water for irrigation of crops in the summer months so the potential for applying treated wastewater as an alternative water resource for irrigation purposes is huge. Given that all requirements for the protection of environmental and human health are met, the reuse of treated waste water could save a large amount of freshwater which now is used to cover the needs of irrigated agricultural land. The large cost of treatment and transportation and the strict legislative framework do not facilitate the wide uptake of this practice. The new EC directive with the less strict requirements is expected to raise the potential for Treated Waste Water (TWW) reuse.

Olive crops in Greece and Arta

Olive groves, both for olive oil and table olives production, are predominant in the Mediterranean basin but are also present in other regions with similar climate, reaching 10.8 Mha worldwide (FAO, 2017). Greece is globally among the three leading olive producing countries along with Spain and Italy. The country's olive area is around 870,000 ha and it produces almost 2.5 $x10^3$ t of olive fruit annually, contributing the 13% of global production (FAO, 2017). *Olea europaea* L. 'Konservolea' is one of the most important table olive cultivars in Greece. The young olive trees are propagated mainly in nurseries (open or covered) where they are kept for about one year before they are transplanted in the field. Irrigation in the nurseries is in some occasions performed by a water consuming alternative of "flood floor" method where large quantities of water flood the basin of the nursery and then the excess water is disposed in the environment. This is the standard practice in the nurseries at the plain of Arta (Region of Epirus, North Western Greece) which is one of the most significant areas for Konservolia table olive production in Greece.

Objectives of del 5.1.1 (Waste water reuse experiment)

The objective of the present study is to evaluate the possibility of applying municipal treated waste water (MTWW) to young olive trees for irrigation purposes and to study the effects MTWW on plants' growth and physiological status. Since in Arta the surface irrigation in olive tree nurseries is the most common irrigation practice and large quantities of water are consumed in this way, we evaluated the effect of municipal treated wastewater on plants in order to assess the possibility of applying TWW for agricultural irrigation as an alternative water resource.

Material and methods

Experimental site

The experiment was carried out at the premises of University of Ioannina – Department of Agriculture in the Kostakii Campus (latitude 39^{o} 0.7’N, longitude 20^{o} 56’E, altitude 5m) near Arta, at the northwestern part of Greece. The experimental site operated as demonstration site, open to anyone interested.

The climate in the area is typical Mediterranean with rainy cold winters and hot and dry summers. The mean annual average temperature is 17,2 ^{o}C and the average annual precipitation reaches the 1084 mm concentrated mainly during the winter months. The experiment was conducted in the period from May to November 2019 and repeated in the same period (May to November) in 2020.

Experimental design

Treatments

The experiment studies the effect of irrigation with treated wastewater on young olive trees’ growth and physiological status. The treatments applied in the experiment were the following:

1. Irrigation with municipal treated waste water and full quantity of fertiliser (TWW)
2. Irrigation with municipal treated waste water and half quantity of fertiliser (TWW_1/2F)
3. Irrigation with tap water and full quantity of fertiliser (TW)
4. Irrigation with tap water, 10% zeolithe substrate and full quantity of fertiliser (zeo)

Treatments were arranged in a completely randomized design. The number of young olive plants for each treatment was ten (n=10). Each plant was considered as a single replication.

Preparation activities

Plant material

Fifty (50) uniform one-year-old young olive plants of Konservolia Arta PGI cultivar (*Olea europaea* l. cv Konservolea) were supplied by local nursery accompanied with their phytosanitary certificate. Single stem young olive trees had an average height of 70 cm. The rootstock and the grafting were of Konservolia cultivar.

Transplantation – acclimatization - establishment

The plants were transplanted to three liter pots filled with sandy loam soil collected from the area. The pots were kept under ambient conditions and in shade for at least one month and a half. Then they were transferred in the nursery in order to prevent rain from affecting the experiment. During acclimatization period all plants were irrigated with tap water. After the establishment of the plants in the nursery they were subjected to the different treatments described above.

Figure 1 Transplantation and establishment of plants in the nursery

Water resources

Tap water

Tap water was provided by Arta's Municipal Water Supply and Sewerage Company. The chemical ~~physical~~ properties of tap water are summarized as: pH=7,63 and EC=0,58 dS m^{-1}.

Recycled Water

Recycled water was provided by the Arta's Municipal Waste Water Treatment Plant operating for Arta's Municipal Water Supply and Sewerage Company. The recycled water had undergone tertiary treatment. Recycled water was collected the day of irrigation. The chemical properties of recycled water such as pH and EC were monitored in each replenishment and in average are summarized as an average pH=7,53 and EC=1,02 dS m^{-1}.

Measurements – monitoring

Soil moisture

Soil moisture was constantly monitored at three representative pots with EC5 soil sensors (Meter Group, Inc.)

Microclimate (temperature, RH and solar radiation)

Relative humidity, temperature and atmospheric pressure were constantly monitored with a microclimate sensor - Passive Radiation Shield (ATMOS-l4 w, Meter Group, Inc.). Solar radiation was constantly monitored with a pyranometer (PYR Solar Radiation Sensor, Meter Group, Inc.)

Figure 2 Left: Microclimate monitoring (pyranometer and microclimate sensor). Right: Pot weighing for the determination of daily water needs

Water needs and irrigation schedule

Over the experimental phase all plants were irrigated according to their actual water needs based on plant-soil system evapotranspiration. Irrigation volume was calculated every week based on the difference of the weight of the system pot-plant early in the morning and the weight of the system pot-plant at the same time in the next morning. Precisa 60000 G SCS was used for the weighing of the pots.

Plant development

Growth development (central stem length, stem diameter, number of leaves, lateral shoots length, number of lateral stem leaves)

Plant development was measured at a monthly basis. The length of the central stem was measured from the height of 10 centimeters from the graft-scion basal point to the top of the plant. The number of lateral shoots developed each month was counted and the length of lateral shoots was also measured from the basal point of the lateral shoot to the top of the shoot. Additionally, the number of leaves of both the central and lateral shoots were counted. Stem diameter was measured 10 cm over the graft-scion basal point.

Figure 3 Growth development measurement (height, stem diameter)

Plant biomass (fresh and dry weight of leaves, shoots and roots)

Plant biomass was measured two times during the experiment, at the mid term (27/8) and at the end of the experiment (9/11). In each sampling (mid term and end of the experiment) five of the total ten plants (replications) of each treatment were harvested and divided into leaves, stems and roots. Olive plant tissues were washed with distilled water and dried on a filter paper. Then plant tissues were dried at 70 ^{o}C for 48 hours and the leaf, stem and root dry weights for each plant were obtained.

Leaf area

Leaf area was measured twice during the experimental period, at the midterm (27/8) and at the end of the experiment (9/11). Leaf area of harvested plants in each sampling (as described above) was measured by a leaf-area-meter AM 300 (ADC Bioscientific Ltd.).

Pigments (chlorophyll and carotenoids)

Chlorophyll a, chlorophyll b and carotenoids

Chlorophyll a, chlorophyll b and carotenoids content were measured according to (Lichtenthaler and Buschmann 2001). A quantity of 0,10 g of fresh olive leaves were homogenized using a pestle and mortar in 10 ml of pure acetone and were centrifuged at 3000 for 5 minutes in a centrifuge (Biofuge primo R, Heraeus). The absorbance of the extract was measured using a spectrophotometer (V-630 UV Visible, Jasco) at 661,6; 644,8 and 470 nm.

Figure 4 Pigments extraction and measurement procedure

Stomatal conductance

Stomatal conductance was measured twice during the experimental period, at the midterm (27/8) and at the end of the experiment (9/11) at all replications of each treatment by a leaf porometer AP4 (Delta-T Devices).

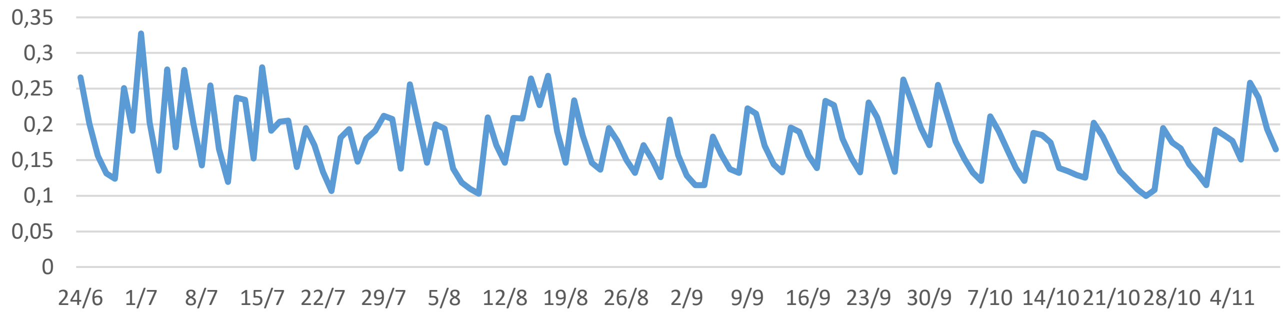
Statistical Analysis

Statistical analyses was performed with SPSS software, 20.0 (IBM Corp. 2011). The One Way Analysis of Variance (ANOVA) was applied to compare the significant differences between the values of all measured parameters using the LSD test (a≤0.05).

Results

Soil moisture

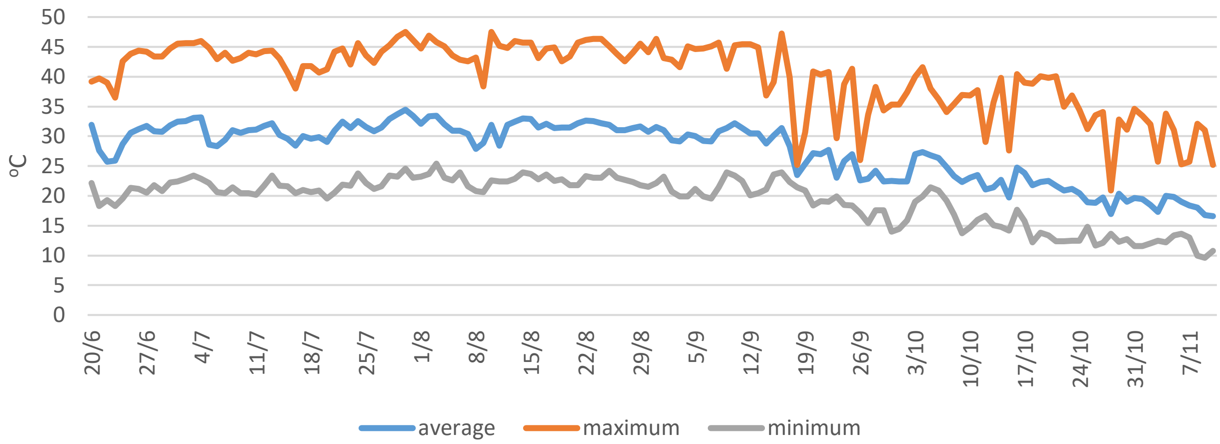
The variation of soil moisture is presented in Graph 1. The peaks represent the irrigation events. Pots were irrigated according to their water needs.



Graph 1 Pot soil moisture over the experimental period (mean of three representative pots)

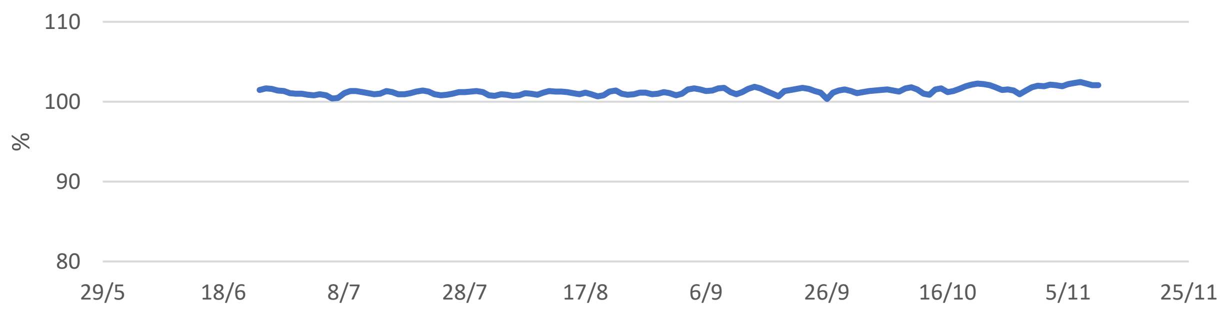
Microclimate (temperature, RH and solar radiation)

The average temperature ranged between 34,4 °C and 16,6 °C during the experimental period (late June – early November). The mean maximum temperature was 43,8 °C during summer months and 36,3 °C during the autumn months while the average minimum temperature ranged between 19,2 °C during the summer months and 16,6 °C during the autumn months.

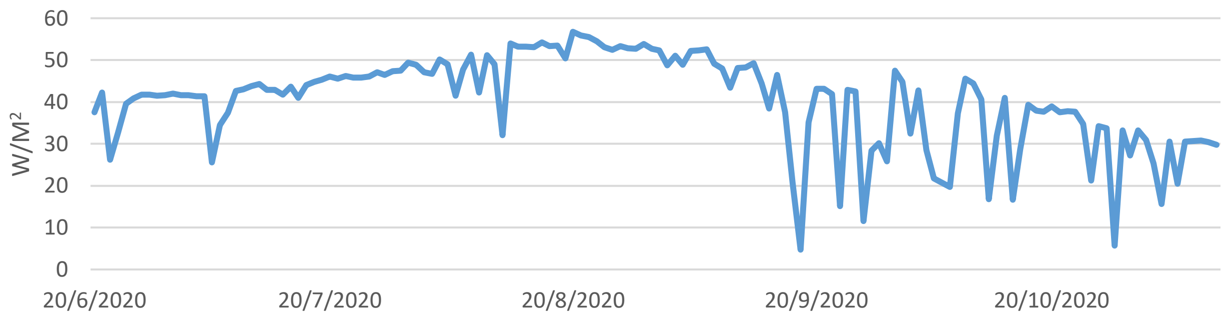


Graph 2 Average, maximum and minimum temperature during the experimental period

The mean Relative Humidity was around 100% during the experimental period while the average solar radiation was 40,5 W/m^2 and fluctuated between 56,8 W/m^2 and 4,7 W/m^2. The average in the summer months was 45,9 W/m^2 and in the autumn months was 34,9 W/m^2.



Graph 3 Average daily Relative Humidity during the experimental period



Graph 4 Average daily solar radiation during the experimental period

Water needs

Over the experimental period all plants were irrigated according to their actual water needs based on plant-soil system evapotranspiration. Irrigation volume was calculated every week based on the difference of the weight of the system pot-plant early in the morning and the weight of the system pot-plant at the same time in the next morning. Table 1 summarises the monthly amount of water applied to each young olive tree during the experimental period.

Table 1 The monthly amount of water per plant (ml) applied for irrigation of young olive trees during the experimental period

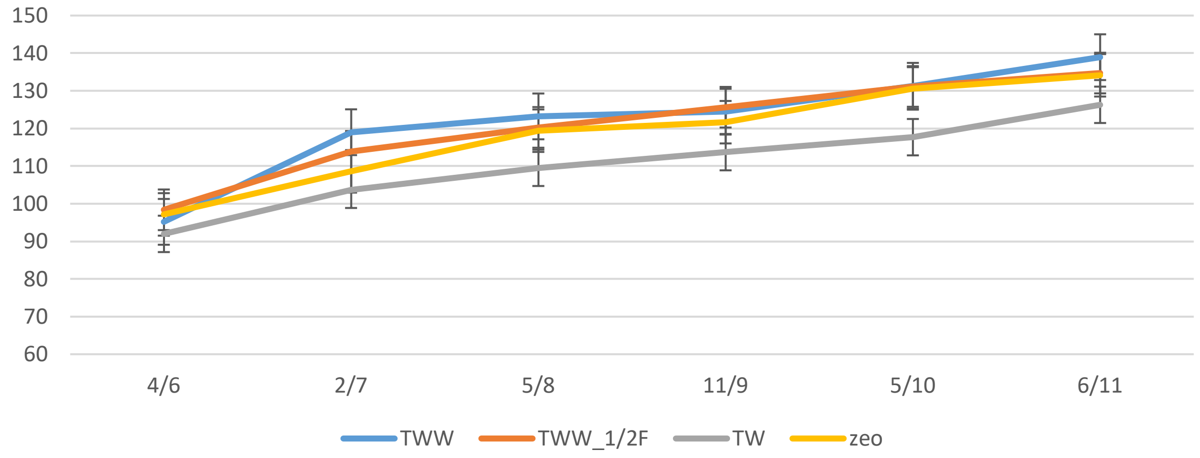
	June	July	August	September	October	November
Water per plant (ml)	820	3700	4800	3500	2450	700

Plant development

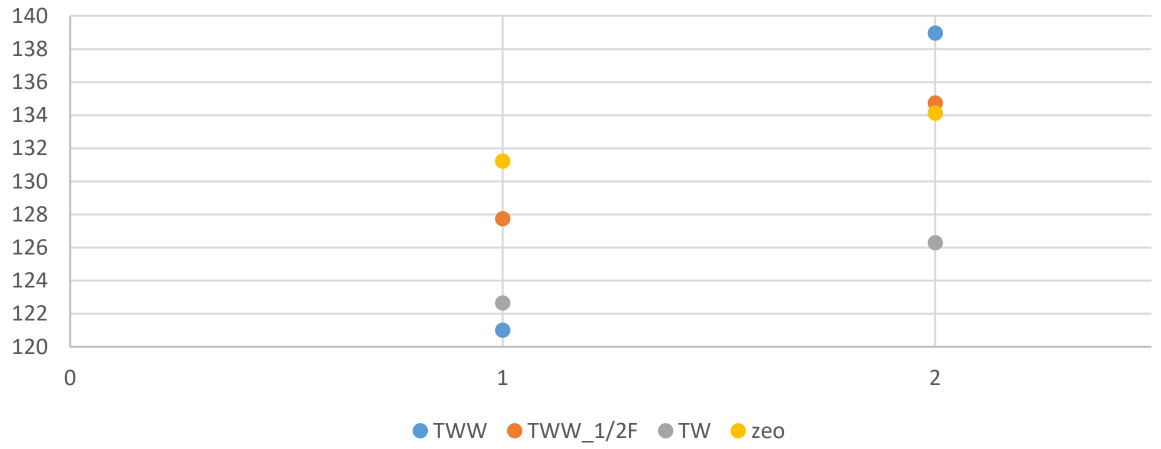
Growth development (central stem height, stem diameter, number of leaves, lateral stem height, number of lateral stem leaves)

Central and lateral stems

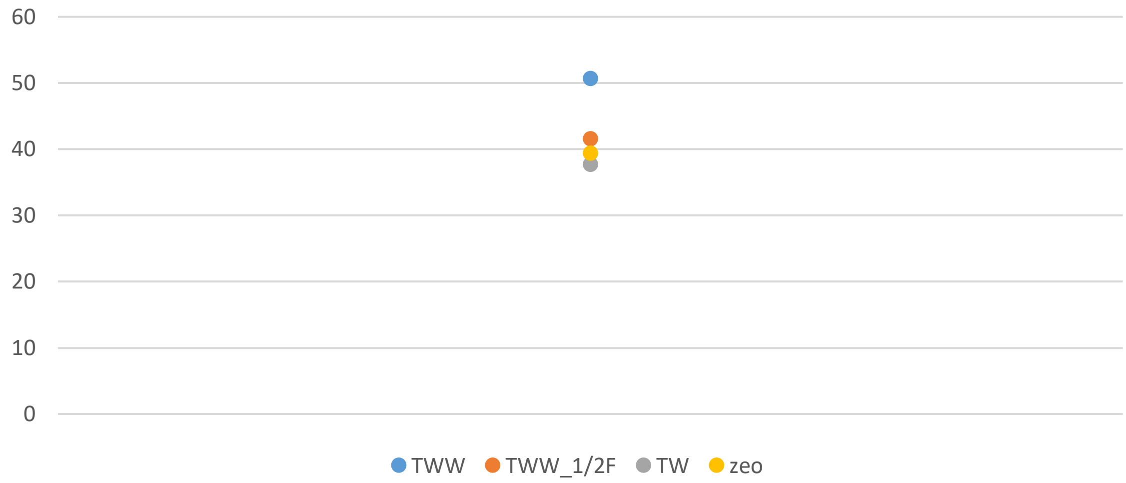
The height of each plant was measured as the sum of the main stem height and the lateral stems length. No statistical significant difference was observed between the treatments neither in the midterm measurement (a=0,375>0,05) nor in the end of the experiment (a=0,360>0,05) (Graph 6), although TWW, TWW_12F and zeo exhibited in absolute numbers a better performance than the control treatment (TW). The same was observed also at the several successive measurements during the experimental period (Graph 5). There was also observed not statistical significant difference at the development rate between treatments both in midterm (a=0,203>0,05) and end of experiment measurements (a=0,667>0,05) (Graph 7).



Graph 5 Height development during the experimental period (six successive measurements)



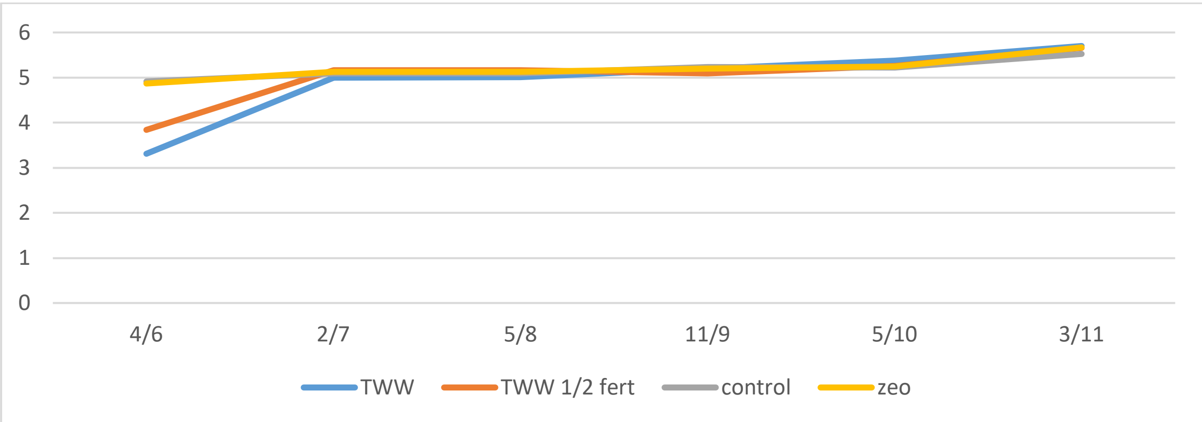
Graph 6 Mean height of young olive trees at midterm sampling (1) and in the end of the experiment (2)



Graph 7 Development rate of young olive trees at the end of the experiment

Central stem diameter

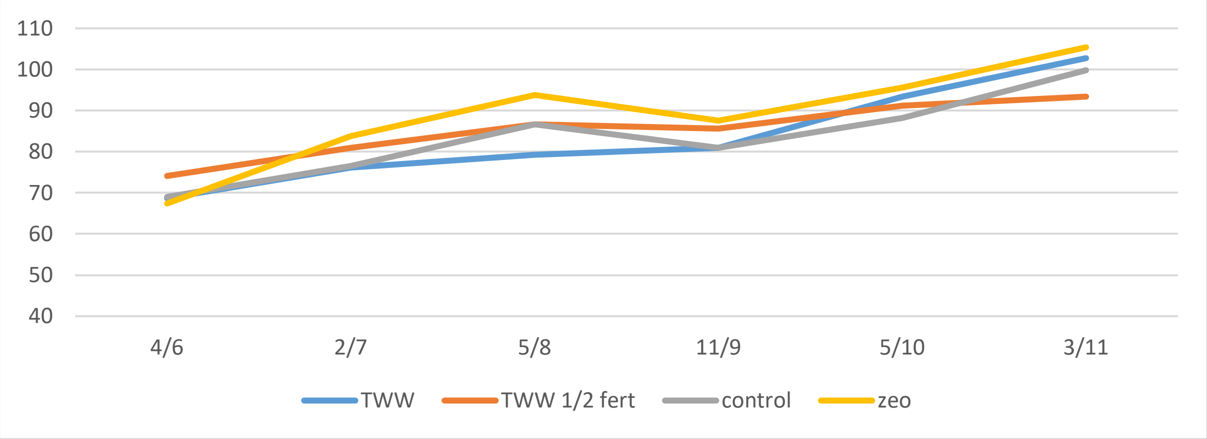
No statistical significant difference was observed among treatments for the development of the central stem at the end of the experimental period (a=0,680>0,05) although in absolute numbers TWW, TWW 1/2Fand zeo treatments exhibited better performance than the control (TW). The same was observed during the entire experimental period (six successive measurements) and the midterm measurement (a=0,134>0,05) (Graph 8).



Graph 8 Central stem of young olive trees development during the experimental period (six successive measurements)

Number of leaves

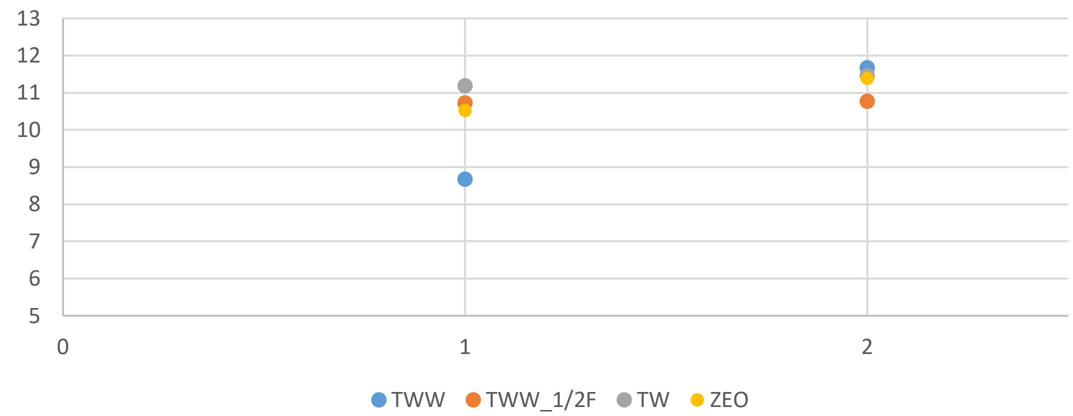
Following the above observed trend the number of leaves of the young olive trees (which was counted as the sum of leaves on the central and lateral stems) did not exhibit any significant statistically difference between treatments (a=0,680>0.05).



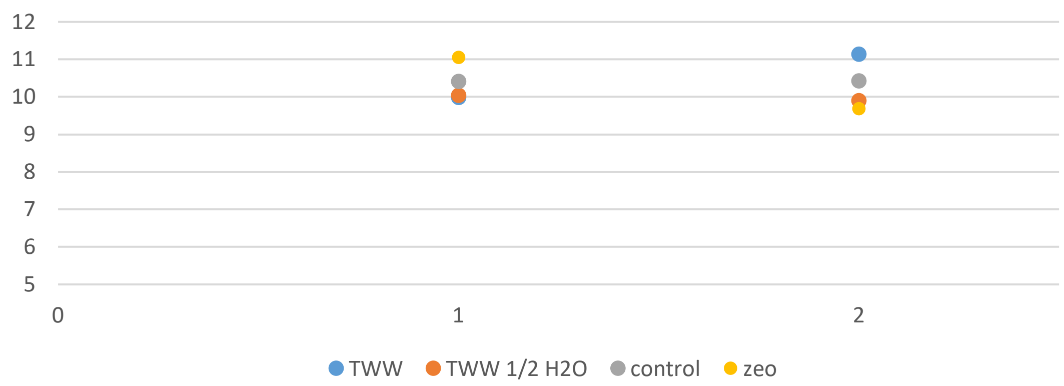
Graph 9 Number of leaves of young olive trees during the experimental period (six successive measurements)

Fresh dry weight of leaves, shoots and roots

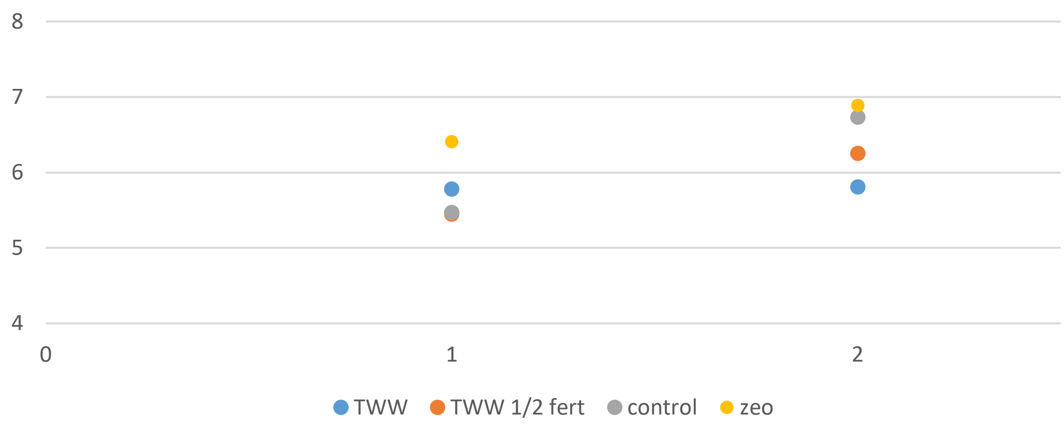
There was not observed any statistically significant difference for the dry weight of leaves (a=0,103>0.05), stems (a=0,418>0.05) and roots (0,619>0.05) in the end measurement (Graph 10; Graph 11; Graph 12).



Graph 10 Dry weight of leaves of young olive trees at midterm measurement (1) and at the end of the experiment measurement (2)



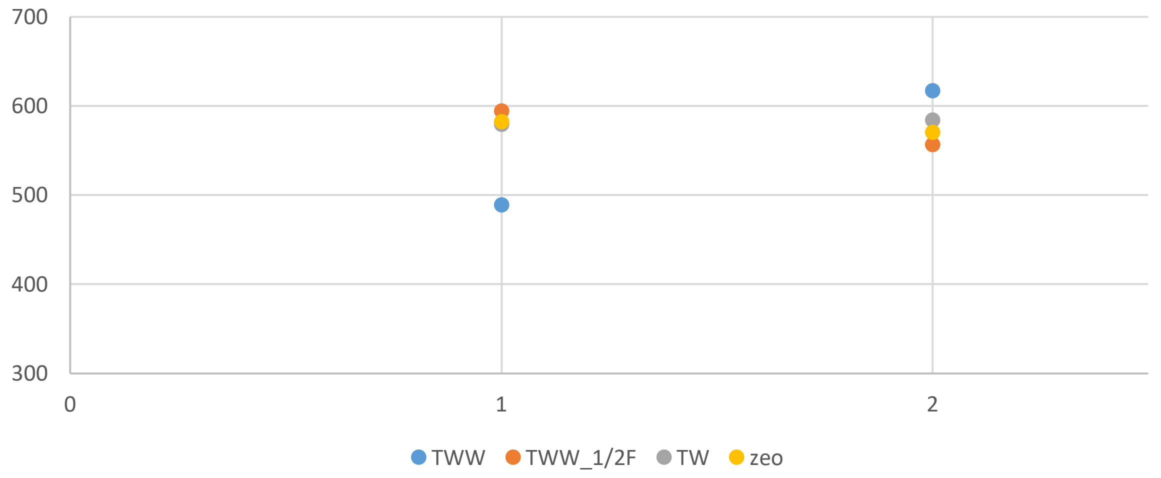
Graph 11 Dry weight of stems of young olive trees at midterm measurement (1) and at the end of the experiment measurement (2)



Graph 12 Dry weight of roots of young olive trees at midterm measurement (1) and at the end of the experiment measurement (2)

Leaf area

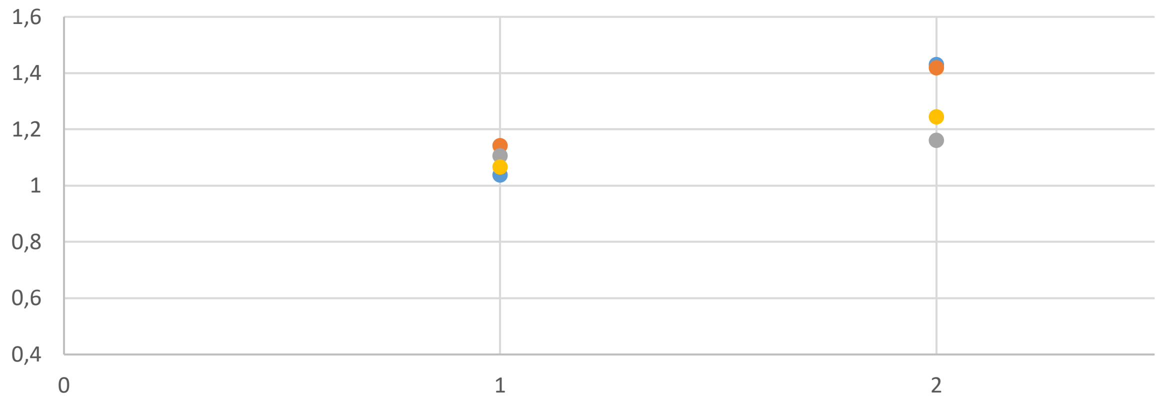
Leaf area of young olive trees did not exhibit any statistically significant difference between the treatments in the end of the experiment (a=0,474>0,05) although in the midterm sampling TWW treatment differed statistically significantly from all the other treatments (a=0,01<0,05).

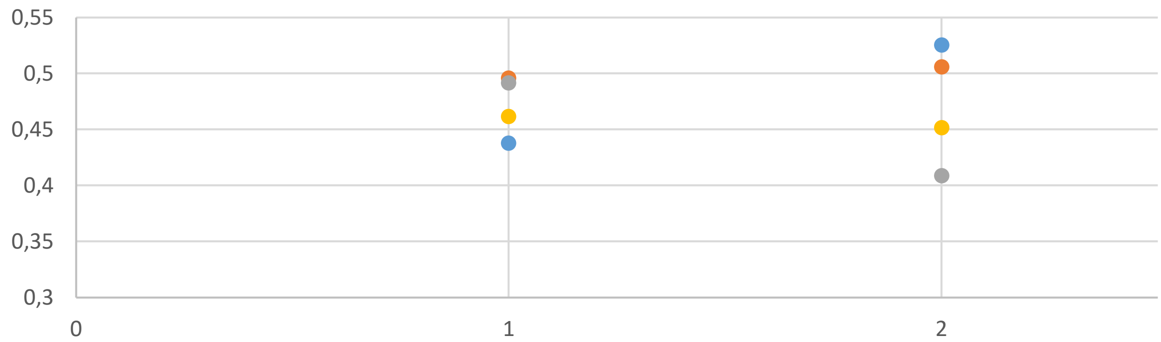


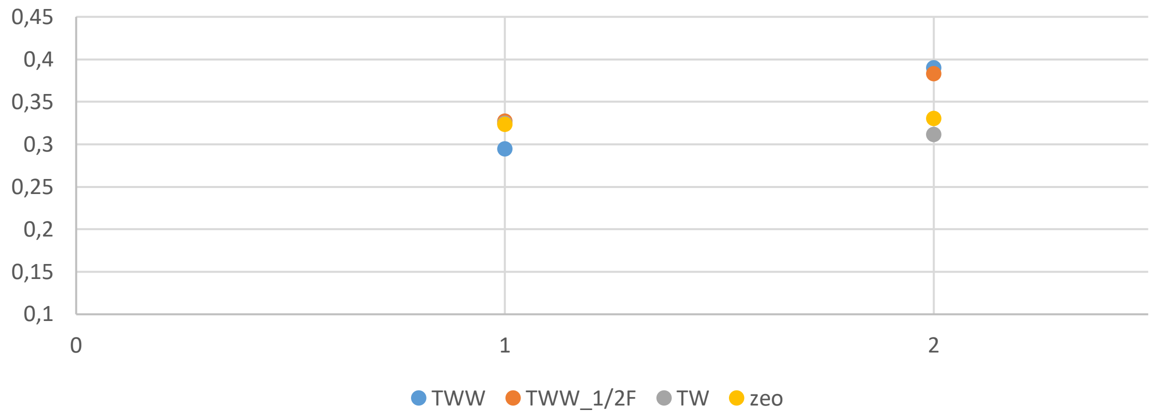
Graph 13 Leaf area of young olive trees in midterm (1) and end of the experiment (2) measurement

Pigments (chlorophyll carotenoids)

No statistically significant difference was observed in the values of chlorophyll a, b and carotenoids neither in the midterm sampling (a= 0,629>0,05; a= 0,415 >0,05; a=0,480>0,05 respectively) nor in the end of the experiment sampling (a=0,137>0,05; a=0,261>0,05; a=0,111>0,05) (Graph 14).



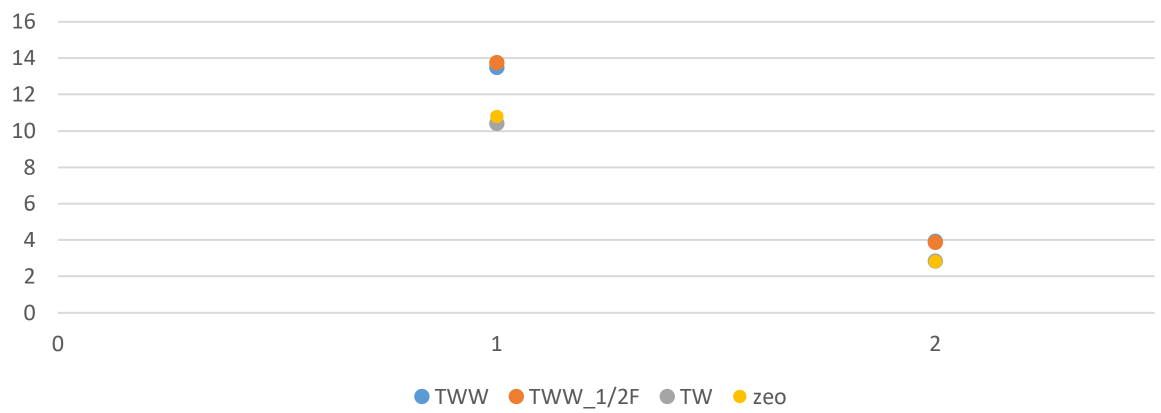




Graph 14 Chlorophyll a, b and carotenoids of young olive trees' leaves at midterm sampling (1) and in the end of the experiment (2)

Stomatal resistance

Stomatal resistance did not exhibit any statistically significant difference between treatments in both of sampling events, at the midterm (a= 0,836>0,05) and end of the experiment (a=0,248>0,05). It has to be mentioned though that the values of the two measurements differed statistically (a=0,000<0,05) depicting presumably the stress that plants suffered in the first measurement due to high temperatures (over 40 ^{o}C) (Graph 15).



Graph 15 Stomatal resistance in young olive trees leaves at midterm sampling (1) and in the end of the experiment (2)

Discussion

Treated waste water is a widely recommended as an alternative water resource in order to cope with water scarcity. Although there are several concerns regarding its use such as human health concerns if not treated adequately, soil-plant interactions (accumulation of salts and heavy metals in the soil and plant sensitivity and tolerance) (Kokkinos, et al. 2015) its availability in large amounts throughout the year constitutes it as a high priority in SDG-6 for global uptake.

In the present work we evaluated the application of treated municipal waste water for irrigation purposes on young olive trees as an alternative fresh water. The findings showed no negative effects on plants' growth and status. Growth characteristics of young olive trees such as height, stem diameter, number of leaves, dry weight of leaves, stems and roots did not exhibit any statistically significant difference compared to the irrigated with tap water plants, although in absolute values treatments with TWW performed better than the tap water treatment. The same was also observed in other parameters such as chlorophyll, carotenoid content and stomatal resistance. Many researches have underlined the benefits of treated waste water reuse focusing mainly on its high nutrient content which could lead to a decrease in fertilisers application (Barbosa, et al. 2017) (Hassena, et al. 2018) (Petousi, et al. 2019) (Ilias, Panoras and Angelakis 2014). We did not observe such a performance in the present work although in absolute values TWW treatments performed better than TW treatment. Perhaps the experimental period was short and the amount of water applied to young olive trees was not adequate to demonstrate any observable effects. The total amount of water that each young olive received (irrigated either with TWW or TW) based on its actual water needs during the entire experimental period (5,5 months) was almost 16.000 ml. That means that each plant that was irrigated with treated waste water saved 16 lt of fresh water in almost half a year. Referring to larger units such as those existing in nurseries we can have an idea of the amount of fresh water that could be saved when irrigating with TWW as an alternative water resource.

Based on our findings we believe that short period irrigation with treated municipal waste water can substitute irrigation with fresh water of young olive trees without causing any unfavorable effects on their development and physiological status.

Synopsis in English language (Abstract)

The present report investigates the possibility of shifting to alternative water resources for irrigation and more specifically to the application of municipal treated wastewater for irrigation in agriculture in order to cope with water scarcity. Young olive trees of Konservolia cultivar (*Olea europaea* L. 'Konservolea') were irrigated with municipal treated wastewater (TWW) provided by the local Waste Water Treatment Plant of Arta (Northwestern Greece) and development and physiological status were studied. At the end of the experiment no statistically significant differences were observed between plants irrigated with treated waste water and those irrigated with tap water. There were no negative effects observed on the development and physiological status of young olive trees irrigated with TWW. On the other hand, TWW didn't enhance plant development as observed in other studies. TWW could be safely applied to young olive trees for at least a short period irrigation rendering this alternative as an important water saving practice.

Σύνοψη στην ελληνική γλώσσα (Περίληψη)

Η παρούσα αναφορά μελετά τη δυνατότητα αξιοποίησης εναλλακτικών πηγών νερού και πιο συγκεκριμένα επεξεργασμένα αστικά λύματα για την άρδευση καλλιεργειών ως μέτρο αντιμετώπισης της λειψυδρίας. Νεαρά δενδρύλλια Κονσερβολιάς (*Olea europaea* L. 'Konservolea') αρδευτήκαν με επεξεργασμένα αστικά λύματα από τη Μονάδα Επεξεργασίας Λυμάτων της πόλης της Άρτας. Μελετήθηκε η ανάπτυξη και η φυσιολογική κατάσταση των νεαρών δενδρυλλίων ώστε να εκτιμηθεί η επίδραση των επεξεργασμένων αστικών λυμάτων στα φυτά. Στο τέλος της πειραματικής περιόδου δεν παρατηρήθηκαν στατιστικά σημαντικές διαφορές μεταξύ των φυτών που δέχθηκαν τη μεταχείριση με επεξεργασμένα λύματα και αυτών που ποτίστηκαν με νερό δικτύου ύδρευσης. Δεν παρατηρήθηκαν αρνητικές επιπτώσεις στην ανάπτυξη και τη φυσιολογική κατάσταση των φυτών που ποτίστηκαν με επεξεργασμένα λύματα από την άλλη όμως δεν παρατηρήθηκε και αύξηση της βλάστησης όπως σημειώνεται σε άλλες σχετικές μελέτες. Τα επεξεργασμένα λύματα θα μπορούσαν να εφαρμοστούν με ασφάλεια σε δενδρύλλια ελιάς τουλάχιστον για περιορισμένη χρονική περίοδο, καθιστώντας αυτή την εναλλακτική, σημαντική πρακτική εξοικονόμησης φρέσκου νερού.

Sinossi in lingua italiana (Riassunto)

Il presente raporto prova di verificare la possibilita di utilizzare le acque reflue depurate per l' irrigazione dei coltivazioni come un metodo di affrontare la scarcita d' acqua. Giovanni olivi di un anno di Konservolia cultivar (*Olea europaea* L. 'Konservolea') sono stati irrigati con acque reflue depurate fornite dall' Impianto di Depurazione delle acque reflue urbane della cita di Arta in Grecia. Sono statti studiati lo sviluppo e lo stato fisiologico per valutare l'effetto delle acque reflue sulle piante. Alla fine del esperimento non sono stati osservati effetti negativi sullo sviluppo e sullo stato fisiologico dei giovani olivi che hanno accetato il tratamento a rispetto alle acque reflue. D'altra parte, le acque reflue non hanno migliorato lo sviluppo delle piante come e stato osservato in altri studi. Le acque reflue depurate potrebbero essere applicati per irrigazione dei giovanni olive almeno per un breve periodo di tempo, redendo questa alternativa una importante prattica per risparmiare acqua fresca.

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