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Editor: Dr. Georgios Koubouris

With the contribution of the LIFE + financial instrument of the European Union to the project “OLIVECLIMA-Introduction of new olive crop management practices focused on climate change mitigation and adaptation”
Dear Colleagues,

During the past year, a group of devoted people worked hard and with great enthusiasm to prepare this event and welcome you in Chania, Greece for the International Conference “Climate Changing Agriculture”. On behalf of all involved team mates I would like to express my pleasure for meeting you, having the chance to be informed of your research achievements and exchange views for climate change mitigation and adaptation.

This international conference is one of the final deliverables of oLIVE-CLIMA project. The oLIVE-CLIMA project (LIFE 11 ENV/GR/942), "Introduction of new oLIVE crop management practices focused on CLIMAte change mitigation and adaptation" (oLIVE-CLIMA) is funded by 50% by the financial instrument Life + of the European Union and has a total budget of 3.649.373 € (EU contribution 1.822.436 €). It was launched in October 2012 and will be completed in September 2017. The project partners are the following: Development Agency of Eastern Thessaloniki’s Local Authorities-ANATOLIKI S.A., Institute for Olive Tree, Subtropical Crops and Viticulture HAO DEMETER, Department of Soil Science of Athens HAO DEMETER, Soil and Water Resources Institute Former Land Reclamation Institute HAO DEMETER, University of Basilicata, Rodax Agro E.P.E., AGROTYPOS S.A., NILEAS Farmers Group, Agricultural Cooperatives of Peza, Agricultural Cooperatives of Mirabello.

This edition contains papers presented in the conference following peer review and selection between a larger pool of submitted research works.

Many thanks to the LIFE programme for funding as well as all the involved institutions for co-funding and hard work. We wish you all a fruitful participation in the conference and a pleasant stay in Chania.

Kind regards,

Dr. Georgios Koubouris
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DETECTION OF PHYSIOLOGICAL TRAITS AND REFLECTANCE INDICES IN OLEA EUROPAEA L. SAPLINGS SUBJECT TO THE INTERACTION OF WATER STRESS AND NITROGEN AVAILABILITY.

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Abstract
The relation of reflectance indices to leaf gas exchange, optical based indices related to leaf nitrogen (NBI) and chlorophyll (Chl) content parameters were studied in olive (Olea europaea) saplings subjected to the interaction of nitrogen availability and water stress. Water deficit significantly affected leaf water potential (Ψl), photosynthesis (A) and stomatal conductance (gs). These parameters were also significantly reduced by nitrogen deprivation in well-watered olive plants. All physiological parameters fully recovered five days after re-watering (RW). Dualex measurements of leaf N content showed a significant difference between the two fertilization treatments. Leaf reflectance indices were compared to physiological and water status parameters. Strong correlations were observed between the photochemical reflectance index with both A and gs. The relative depth index was also positively correlated with both gs and Ψl. Differences in nitrogen content were detected by the NRI index. Our study confirms that variations in the physiological status of olive trees can be accurately detected remotely; therefore, non-invasive sensing technologies can be successfully used to assess plant water and nutritional status, thus enabling effective crop management.

Keywords
Drought, Dualex sensor, Leaf gas exchange, Nitrogen, Spectral reflectance, Water potential.

Introduction
In Mediterranean-type agroecosystems characterized by unpredictable rainfall, plant features related to the regulation of water and nitrogen utilization are key components of adaptation to the environment (Dbara et al. 2016; Feller et al. 2017). Knowledge of these features is required to establish reliable irrigation-scheduling and precise nitrogen (N) management protocols. Information regarding the water and N status of olive trees (Olea europaea L.) is essential for managing growth to optimise yields and olive oil quality. It is of paramount importance to improve non-invasive phenotyping methods to monitor water and N relations and photosynthetic status in plants experiencing water stress (Sun et al. 2008; Marino et al. 2014).

In upcoming years the development of UAVs (Unmanned Aerial Vehicles), miniaturized hyperspectral devices and thermal cameras are expected to play a significant role in expanding the use of high-spectral resolution reflectance data and high-spatial resolution thermal data in precision agriculture. Hyperspectral data could enhance the accuracy of mapping-based management by providing effective early detection (and distinction) of water and nutrient stress.

To detect water and N needs to increase water productivity, studies have recently been
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performed with remotely sensed vegetation indices to assess physiological traits associated with plant water status (Sun et al., 2008; Garbulsky et al., 2011; Marino et al. 2014; Sun et al., 2014). The methodology is based on a number of visible (Vis)- and near infrared (NIR)-based indices as indicators of photosynthetic activity (Gamon et al., 1997) and water status (Sun et al., 2008; Elsayed et al., 2011; Sun et al., 2014). Similarly, a new generation of chlorophyll (Chl) fluorescence meters, that measure epidermal flavonoids (Flav), chlorophyll (Chl) and indirectly N content in leaves can also applied to the measurement of plant physiological status.

Precise N management requires accurate detection of leaf N status. Spectral reflectance indices have proven to be good indicators of plant N status. A number of studies have been undertaken on different crops to determine the relationship between the reflectance obtained in the VIS and NIR wavebands and rates of fertilizer application (eg. Zhao et al., 2005). However, to our knowledge, no studies have been performed on tree crops. Moreover, these spectral reflectance indices are also largely influenced by water status and the impact of interaction between water and nutrient stress on these indices is unclear. Therefore, to accurately assess the links between concomitant variations in the physiological plant status and leaf reflectance, non-invasive sensing technologies were evaluated in olive trees subjected to the interaction between water deficit and N stress.

Materials and Methods

One-year-old saplings of olive (Olea europaea L., cv Leccino) were grown outdoors under natural sunlight irradiance in Sesto Fiorentino (FI), Italy, in 1.5L pots containing a mixture of sand:peat (3/2, v/v). A subgroup of eight plants (-N) were fertilized once a week using a minus nitrogen Hoagland’s solution (Hershey, 1994) with full Hoagland’s solution was provided weekly to the rest of saplings (+N). The differentiated fertilization started one month before the measurements and continued during the experiment.

The following measurements were performed at midday before subjecting plants to drought treatment (T0) and repeated four times (T1,T2,T3 and RW) during and after the water stress: leaf water potential was recorded using a Scholander-type pressure chamber (SKPM1400, Skye Instruments, Llandrindod Wells, UK); photosynthesis (\( A \)) and stomatal conductance (\( g_s \)) were measured under cuvette conditions of 2000 μmol m\(^{-2}\) s\(^{-1}\) photosynthetically active radiation (60% red, 10% blue and 30% green light), leaf temperature of 25°C and relative humidity of 60% using a portable gas exchange system (Ciras 3, PP Systems, USA); optical based indices related to leaf nitrogen (NBI) and chlorophyll (Chl) content were gauged using the Dualex sensor (ForceA, Orsay Cedex, France); leaf-level spectral reflectance was measured under natural sunlight with a spectroradiometer (ASD FieldSpec 3, Analytical Spectral Devices Inc.,USA) operating in the spectral range between 350 and 2000nm. Reflectance measurements were conducted in clear weather conditions and a Spectralon white standard panel was used for calibration before every measurement. ViewSpecPro (ASD) software was used to process spectra and derive the reflectance indices: Photochemical Reflectance Index (PRI), calculated as \((R_{531} - R_{570})/(R_{531} + R_{570})\), where R is the reflectance at the wavelength indicated in the sub-indices (Gamon et al., 1992); Nitrogen Reflectance Index (NRI), derived as near-infrared / green region reflectance ratio (Diker and Bausch, 2003); Relative depth index (RDI) as 100\((R_{max} - R_{min})/R_{max}\), where \(R_{max}\) is reflectance at 1116nm and \(R_{min}\) is the minimum reflectance between 1120 and 1250nm (Rollin and Milton 1998).
Irrigation was suspended in four +N and four -N plants until gs decreased to less than 40% compared to well-watered controls (T1), then deficit irrigation was maintained on stressed plants for two weeks (T1 and T2). After T2, the olive saplings were re-watered to pot capacity and measured again after five days (RW).

**Results and Discussion**

Water management and eco-friendly fertilization are crucial issues that limit plant productivity world-wide. Effective use of renewable resources in agriculture is a tangible challenge in vast areas of the globe. To this end, remotely sensed vegetation indices are increasingly used as cost-effective reliable plant-based indicators to assess physiological traits associated with plant water and N status (Peñuelas & Filella 1998).

Figure 1 shows the time course of midday leaf water potential ($\Psi_l$), $g_s$, and $A$ in nitrogen stressed and fully fertilized plants during the drought stress period and subsequent water recovery. All parameters remained significantly lower in drought stressed plants compared to controls after initiation of the soil dehydration (T1) and during the deficit irrigation (T2 and T3), before full recovery five days after re-watering (RW). Water potential decreased dramatically between T1 and T2 (Fig 1.a), due to a period of unusually high environmental temperature and corresponding evapo-traspirative demand, and then slightly recovered at T3. Nevertheless, $g_s$ did not change significantly during the same period (Fig. 1.b) suggesting an anisohydric behaviour of the plant (Centritto et al., 2011). Photosynthesis followed the same trend of water-related parameters but never decreased to less than 40% of control values (Fig 1c). The nitrogen deprivation treatment did not affect photosynthetic capacity in both water stress and control plants.

![Figure 1](image-url)  
*Figure 1*. Time courses of (a) midday leaf water potential ($\Psi_l$), (b) stomatal conductance ($g_s$) and (c) photosynthesis ($A$) of nitrogen fertilized (circles) and unfertilized (squares) olive saplings during drought stress and after re-watering (RW). Open symbols represent water stressed plants, black symbols are well-watered controls. All data points are means of four plants (two leaves per plant) ± SEM.
Dualex measurements of leaf nitrogen content (Fig. 2.a) show a significant difference between the two fertilization treatments (P<0.001) throughout the measurement period. Progressively lower values in were observed in control than in drought stressed plants, possibly due to of greater dilution and washout of nutrients in the pots receiving full irrigation. As result of the different fertilization treatments, chlorophyll concentration was significantly lower in -N plants (Fig. 2b), because of the strong relationships between nitrogen allocated in thylakoids and leaf chlorophyll content (Evans, 1989).

**Figure 2.** Time courses of (a) Nitrogen Balance Index (NBI) and (b) Chlorophyll index (Chl) measured with Dualex on nitrogen fertilized (circles) and unfertilized (squares) olive saplings during drought treatment. Open symbols represent water stressed plants, black symbols are well-watered controls. All data points are means of four plants (two leaves per plant) ± SEM.

Proximal sensing reflectance indices were compared to physiological and water status parameters directly measured on the leaves (Sun et al. 2008, Marino et al. 2014). Photochemical reflectance index correlated strongly with the photosynthetic activity of the olive plants (Fig. 3a); supporting previous observations at the leaf and canopy level (Sun et al. 2014, Marino et al. 2014, Tsonev et al. 2014). As photosynthetic capacity is strongly affected by stomatal conductance limitations under water deficit conditions, PRI was also positively correlated to $g_s$ (Fig. 3b).
Figure 3. Correlations of photochemical reflectance index (PRI) with (a) photosynthesis (\(A\)) and (b) stomatal conductance (\(g_s\)). Data points are means of four plants (two leaves per plant) ± SEM. Symbols as in Figure 1.

Evaluating the different nitrogen conditions together, RDI assessed water status changes of olive leaves more effectively than other water content-related reflectance indices measured during the experiment that were more strongly affected by foliar nitrogen content (data not shown). Relative depth index was positively correlated with both \(g_s\) and \(\Psi_l\) (Fig. 4a,b). Differences in nitrogen content were detected by the NRI index (Fig. 5a) which also showed a stronger correlation with chlorophyll assessment when using the Dualex sensor (Fig. 5b).

Figure 4. Correlations of relative depth index (RDI) with (a) stomatal conductance (\(g_s\)) and (b) midday leaf water potential (\(\Psi_l\)). Data points are means of four plants (two leaves per plant) ± SEM. Symbols as in Figure 1.

Figure 5. Correlations of Nitrogen Reflectance Index (NRI) with Dualex measured indices NBI (a) and Chl (b). Data points are means of four plants (two leaves per plant) ± SEM. Symbols as in Figure 1.
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Both nitrogen and water availability affect several leaf biophysical and biochemical properties that subsequently influence leaf reflectance spectra. The present study confirms that it could be possible to utilise these spectral changes to remotely detect variations in the physiological and hydrological status of olive cultivations to promptly assess water and nutrition status and instigate the appropriate management strategy.

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References


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CONTRIBUTION OF INDIGENOUS OLIVE GROVE FLORA IN CARBON STORAGE AND NUTRIENT BINDING

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Abstract
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Under the European Commission's LIFE+ program, the 5-year oLIVECLIMA project is being implemented, aiming at transforming olive growing into a tool for tackling / managing climate change and adapting olive growing to new climatic conditions. Among other things, the maintenance of natural weed grass (avoiding soil treatment and chemical weed control) and the appropriate alteration of indigenous weed flora in order to increase carbon storage in the ecosystem of olive groves are also applied. In olive groves from the Prefectures of Messinia (O.P "Nileas"), Heraklion (EAS Pezon) and Lassithi (EAS Meramvellou) the percentage of vegetation cover and the most prevalent weed species were recorded. The content of plant tissue on carbon and nutrients was determined to assess the contribution of indigenous weed to carbon storage in the olive grove. As a result of the analysis, the weeds captured an average of 92, 55, and 80 kg of carbon per hectare in the olive groves of Nileas of N. Messinia, Meramvellou of N. Lasithi and Peza N. of Heraklion, respectively. The next objective will be to modify the weed flora in order to improve its contribution to carbon capture but also to reduce competition with olive trees for nutrients and water.

Keywords: Olive, Weeds, Nutrients, Carbon Balance

Introduction
The sustainability of agroecosystems is an important development parameter today, with constant emphasis on the application of environmentally friendly management models. Intensification of olive cultivation can lead to a significant reduction of biodiversity in general, but also of the composition of weed flora in Greek olive groves in particular (Allen et al., 2006). On the other hand, the way we choose to control weeds is an important parameter for determining the desegregation risk in olive groves (Metzidakis et al., 2012). A basic principle in the modern management systems of olive groves is the conservation of weeds in the olive grove during the winter, in order to reduce the risk of soil erosion. The intervention to change the composition of the winter weed flora of an olive grove can help to increase biodiversity and also to capture more carbon and nitrogen from the atmosphere in the olive grove ecosystem.

In olive groves in the Prefectures of Heraklion (EAS Pezon), Lassithi (EAS of Meramvello) and Messinia (OP Nileas) cultivation practices were applied that contribute to limiting climate change in two ways: a) reduction of greenhouse gas emissions from cultivation of olive trees (b) increasing carbon dioxide capture from the atmosphere to plants and storing it in the soil as an organic substance to improve fertility. In particular, one of the practices applied is the maintenance during winter of natural weed grass (avoiding soil treatment and chemical weed control) and the appropriate modification of indigenous weed flora to increase carbon storage in the ecosystem of olive groves.

This work was carried out in the first year of the program and aimed at initially assessing the amount of carbon and nutrients bound by weeds in olive groves in the three regions to provide a guide for planning future interventions.

Materials and Methods
In April 2013, samples of 70 olive groves were taken in the three olive-growing areas as follows: A. Nileas Producer Group in Messinia: 33, B. Meramvellos Association of Agricultural Cooperatives (EAS) in the Prefecture of Lassithi: 21, C.
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EAS Pezon area in the Prefecture of Heraklion: 16. In each olive grove three areas of 1 m² were selected, from which the above-ground part of the existing vegetation (weeds) was removed. Also, the percentage of vegetation cover in the olive grove and at the sampling points, as well as the most prevalent weed species, was recorded. The samples obtained were measured for the wet and dry weight and then the organic carbon concentration was calculated by the loss-on-ignition method, the total N by the Kjeldhal method, P by the ammonium vanadate method and elements, K, Ca and Mg using an ICP-OES device. From the data obtained, the concentrations were reduced to corresponding amounts per acre. Averages were calculated and the statistical separation between the means was done using One-Way-ANOVA and LSD-test (P <0.05).

Results - Discussion

As a result of recording the weeds, in most olive groves various species of other broadleaf weeds prevailed, while gram-weeds (mainly wild and purple) were significant. In 13 of the 37 olive groves of Crete, Oxalis pes-caprae prevailed. Legumes were the dominant species in a small number of olive groves (just 6 out of 70). As shown in Fig. 1, the amounts of carbon and macroelements were in full proportion in the three regions, suggesting that they were related to the total herbaceous plant stock.

Of the three regions, the highest amounts of carbon and nutrients were found in Nilea, followed by Peza and finally the Meramvello area. This variation is probably related to differences in soil and climate conditions between the three regions. In Western Greece (Nileas) where the rainfall is higher than in Crete, the total plant mass developed was higher. Similarly, in East Crete (Meramvello), where the rainfall is generally lower, while several olive groves in the area are found in shallow, rocky soils with rocky relief, the amount of plant mass developed was the lowest.

In total, weeds captured an average of 92, 55, and 80 kg of carbon per acre in the olive groves of Nilea, Meramvello and Peza respectively. They also removed nitrogen from the soil solution in amounts of 3.8, 1.6 and 2.8 kg / ha, phosphorus 0.8, 0.3 and 0.5 kg / ha, and potassium 5.6, 2, 2 and 3.9 kg / ha, respectively. Carbon capture was relatively low compared to a reference for an olive grove in southern Italy where it was estimated at 286 kg / ha. (Palese et al., 2013). This significant variation may be partly due to climatic conditions that vary from region to region. It is also appreciated that with appropriate modification interventions in the composition of winter weed flora there are significant margins for increasing the carbon bound. At the same time, the total carbon balance of the olive grove can be significantly improved, as the contribution of the vegetation cover to total carbon capture in an olive grove is estimated to be 34-36% (Nardino et al., 2013).

Removal of nutrients from the soil solution makes a percentage of olive trees annual nutrient needs temporarily unavailable, so it is important to select the appropriate time of mowing to encourage the nourishment of the olive trees. For N, in particular, the commitment of an available amount of 3.8 kg per acre corresponds to 32% of the annual olive needs. In this case, the introduction of plants that bind N from the atmosphere (legume) could contribute to the reduction of inputs (fertilization) and competition between olive trees and weeds for N.

The above results will provide a guide for an appropriate modification of the indigenous weed flora (sowing mixture of selected legumes and grasses) to improve
its contribution to carbon sequestration and also to reduce competition with olive trees for nutrients.

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References
Figure 1. Removal of C and macro elements (N, P, K, Ca, Mg) per acre in olive groves from 3 olive areas. Values are averaged from 33 (Nileas), 21 (Meramvello) and 16 (Peza) olive groves ± SE (LSD-test, P <0.05).

(*str= 0.1 ha)
Abstract

Under the European Commission's LIFE + program, the 5-year oLIVECLIMA project is being implemented to transform olive growing into a tool for tackling / managing climate change and to adapt olive growing to new climatic conditions. One of the practices applied is the composting of olives by-products or alternatively other crops for the purpose of returning them to the olive groves in the context of recycling. In June 2013, a large-scale composting effort was launched using the materials available in each region. In the case of EAS Meramvellou, olive leaves and olive-pomace of a three-phase oil mill were used, in the case of EAS Pezon grape bunches and two-phase oil mill waste and in the case of OP. Nileas, olive leaves and chopped olive branches. Characterization of the materials related to the carbon / nitrogen ratio (C / N) but also to a number of other features such as nutrient concentration, humidity, etc preceded the study. In the present study qualitative characteristics of the three composts are presented, such as nutrient content, phytotoxicity and the presence of plant-friendly microorganisms, during the development and after the completion of the composting. As a result of the analysis, the various types of compost are quite varied, probably related to the materials used in each area. With regard to the nutrients, compost of O.P. Nileas has the highest total nitrogen concentration and the lowest C / N ratio.

Key words: Olive, Composting, Carbon Balance

Introduction

The application of environmentally friendly management models in olive growing is nowadays more imperative than ever. This necessity has to do with both acute environmental problems (e.g. climate change, desertification) and the new demands of world trade for products that have been produced in an environmentally sound way. However, these novel needs-trends need to be matched by the real requirements of an agro-ecosystem, particularly with regard to the input-output balance, in order to remain economically viable. Some efforts have been made to produce composts using waste and by-products of agricultural activities from time to time to reduce carbon and nutrient outflow from the field and to solve a number of practical problems such as waste management and improvement of the soil structure (Manios 2004, Manios and Balis 1983).
Within the framework of the European Commission's LIFE + program and the 5-year OLIVECLIMA project, in olive groves in the Prefecture of Heraklion (EAS Pezon), in the Prefecture of Lasithi (EAS Maramvellou) and N. Messinias (OP Nileas) cultivation practices that contribute to limiting climate change are implemented in two ways: a) reduction of greenhouse gas emissions from olive cultivation, b) increased carbon capture from the atmosphere to plants and "storage" of it in the soil in the form of an organic substance, in order to improve the soil fertility.

One of the practices involved is the composting of olive oil by-products (or alternatively other crops) in order to achieve their return to olive groves in the context of recycling. In the summer of 2013, a composting effort began, using the available materials in each region, the results of the first year of which are summarized in the present paper.

Materials and Methods

In the case of EAS Meramvellou (CoMRB), olive oil and olive-pomace of 3-phase olive oil mill were used in a ratio of 3:1, in the case of the EAS Pezon (CoPEZ), olive leaves, grape bunches and two-phase olive oil mill waste in a ratio of 2:1:1, and in the case of O.P. Nileas (CoNIL), olive leaves sliced and olive branches in a ratio of 3:1.

Before composting, volatile solids, organic carbon, total nitrogen and the carbon to nitrogen ratio of both the raw materials and their mixtures were determined.

Mixtures of materials were placed in elongated piles of about 1.2 meters in height. During the process, the temperature and humidity of the compost were monitored and stirring and adding water took place whenever needed. After composting was completed, the physicochemical characteristics of compost (pH, electrical conductivity, volatile solids, organic carbon, total nitrogen, carbon to nitrogen ratio, potassium, phosphorus and nitrate concentration) were determined.

The phytotoxicity of compost was assessed by measuring the germination of tomato seeds in filter paper impregnated with their extracts. The phytotoxicity of the mixtures was monitored during composting in the same way. Finally, an attempt has been made to isolate specific groups useful for plant microorganisms using selective and semi-selective nutrients.

Results and Discussion

Table 1 presents the physicochemical characteristics of the raw materials and composting mixtures used. Depending on the results, additional nitrogen (in the form of NH$_4$NO$_3$) was added, so that the carbon to nitrogen ratio approximates 30.

As a result of the analysis, the various types of compost are quite varied. Table 2 presents the physico-chemical characteristics of compost produced in the three olive-growing areas. Indicatively, pH, electrical conductivity, and nitrate concentration values ranged from 5.86-7.37, 0.57-1.39 mS/cm and 10.0-76.5 ppm respectively. The analysis also showed that composts contain nitrogen, phosphorus and potassium in appreciable concentrations which can help in plant growth. It is also noted that CoPEZ compost has the highest concentration of potassium. This is probably related to the addition to the initial mixture of a two-phase oil mill which, as is known, is rich in potassium.
The phytotoxicity of compost was determined by measuring the germination of tomato seeds in their extracts. Of compost, the highest phytotoxicity is the CoNIL and the smallest the CoMRB (Figure 1A). The differentiation in phytotoxicity may have to do with the materials used and the concentration of phytotoxic substances such as phenolic compounds and organic acids (Manios et al., 1989). The phytotoxicity of the mixtures was monitored during the composting process. Figure 1B illustrates the change in the phytotoxicity of the CoMRB compost mixture at various times of composting. As shown in the figure, phytotoxicity increases in the intermediate phases of the process and decreases again to the end. However, at the dosages used compost in olive cultivation, it is estimated that any phytotoxicity will not have a negative effect on the growth and productivity of olive trees.
Using selective and semi-selective media, microorganisms which are potentially beneficial to plants (effects not shown) were isolated. Such microorganisms isolated are bacteria of the genera Bacillus and Pseudomonas. Their further characterization and evaluation will show if these micro-organisms could have a positive effect on the protection and more generally on the robustness of the plants.

Figure 1. (A) Tomato seed germination (% relative to the control) in CoMRB, CoPEZ and CoNIL compost extracts. (B) Change in tomato seed germination in extracts from the CoMRB mixture at various times of the composting process. Points not shown by the same letter vary considerably according to the Tukey criterion for p≤0.05 (n = 4).

References

EVALUATION OF BY-PRODUCTS FROM OLIVE TREE PRUNING (VARIETY KORONEIKI) AS A MATERIAL TO IMPROVE THE FERTILITY OF THE SOIL AND MITIGATION OF CLIMATE CHANGE
Climate Changing Agriculture

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Summary

Under the European Commission's LIFE + program, the 5-year oLIVECLIMA project is being implemented, aiming at transforming olive oil into a tool for tackling / managing climate change, as well as adjusting olive oil to new climatic conditions. In olive groves in the Prefecture of Heraklion (EAS Pezon) and in Lassithi (EAS of Meramvelo) cultivation practices have been implemented to reduce the adverse effects of climate change. As a result of the analysis of the first year pruning materials, the macro-elements and most of the trace elements measured in the leaves were statistically higher than those in the thin and coarse branches, while the carbon content was higher in the woody tissues. Also, statistical differences of the above data were found between the two study areas, suggesting different fertilization practices or soil-climatic conditions.

Key words: Olea europaea, nutrients, carbon balance

Introduction

Under the European Commission's LIFE + program, the 5-year oLIVECLIMA project is being implemented, aiming at transforming olive oil into a tool for tackling / managing climate change, as well as adjusting olive oil to new climatic conditions. Cultivation practices can contribute to curbing climate change in two ways: a) reducing greenhouse gas emissions from olive cultivation; b) increasing carbon capture from the atmosphere to plants and "storing" form of organic substance to improve fertility (retention of water and fertilizers). In particular, in contrast to the incineration of branches, which is the usual practice applied to olive groves, this project involves the recycling of pruning as soil cover and nourishing material. Pruning byproducts are precious material that can be utilized in the management of the olive grove as a source of nutrients but also as a carbon storage medium. This paper presents the first results, while the measurements will continue for the next four years, so more data will be available for estimating spatial and temporal variability.

Materials and methods

In the spring of 2013, in 4 parcels of the EAS Pezon and in 4 parcels of EAS Miramvelo, the pruning residues from 3 representative trees per parcel were weighed and then separated into thin branches that are usually burned in the field and in thick branches used for domestic heating. The content of plant tissue in carbon (C),
nitrogen (N), potassium (K) and other inorganic macroelements and trace elements such as calcium (Ca), magnesium (Mg), iron (Zn), manganese (Mn) and copper (Cu), (Jones and Case, 1990) to assess the contribution of recycling of pruning to improving soil fertility. Means were calculated and the statistical separation between the means was done using One-Way-ANOVA and the Tukey HSD statistical assay (P≤0.05).

Results and Discussion

From carbon measurements in leaf tissue, thin branches and coarse branches of olive trees of the EAS Meramvellou and EAS Pezon, it was found that the concentrations of coarse branches in carbon were statistically higher than those of fine branches and leaves. Also, the leaves showed significantly lower values in this element than the other two types of tissue. Furthermore, the concentrations of olive leaf carbon of the EAS Pezon were statistically higher than those of the olive trees of EAS Meramello (Figure 1).

Concerning the content of individual plant tissues in nitrogen and potassium, it appears that the concentrations of these elements in the leaves are significantly higher than those of the fine branches, while the concentrations detected in the bulk branches were significantly lower than the two other tissue types (Figure 2A, B). Also, the nitrogen content of the fine branches and leaves of the Meramvello olive trees was statistically higher than the corresponding tissues of the olive trees of Peza (Figure 2A). Furthermore, the concentrations of Meramvello's olive tree leaves in potassium were significantly higher than those determined on the leaves of the Peza olive trees (Figure 2B).

Similarly, calcium and magnesium leaf concentrations appear to be statistically higher than the thin and coarse branches, while the latter are characterized by significantly low values in these figures (Figure 2C, D). Among the Associations, the only significant differences observed were the higher concentrations of magnesium in leaves of the Meramvello olive trees, compared to the olive trees of Peza (Figure 2D).

Finally, as regards the zinc and manganese values, the concentrations of these elements in the leaves and thin branches were significantly higher than those detected in the bulk branches. Also, the zinc content of the leaf and thick branches of the Meramvello olive trees was statistically higher than in the Peza olive trees, whereas only the thin branches manganese content differed between the olive trees of the two associations (Figure 2E, F).

The results of this paper demonstrate that the by-products of pruning are precious material. Pruning material can be utilized in the management of the olive grove as a source of nutrients as well as a carbon storage medium. Leaf and thin branch tissues are an excellent source of macros and trace elements, while thick branches are a carbon depot. The first technique applied is the spreading of branches on the surface of the soil in the rows between the trees and the destruction by a shredder carried by an agricultural tractor. The second technique is the mincing of branches with a shredder. Subsequently, this material is either dispersed on the soil surface or used for composting. Particular attention is needed in the case of pruning from trees with diseases such as verticillium, *Fomes igniarius* etc. so they must also be burned to prevent pathogens from spreading and spread the infection to previously healthy trees. It should be borne in mind that the use of an agricultural tractor for the destruction of branches with a disaster must be avoided in olive groves with a high slope to avoid accidents, as in very rocky soils.
Climate Changing Agriculture

The conservation of the by-products of the pruning has an important contribution to the storage of carbon and other tree crops such as peach (Montanaro et al., 2012), apricot and kiwi (Montanaro et al., 2010). Organic recycling of the orchard, in addition to environmental benefits, also has economic value as it can help reduce production costs (Palese et al., 2013).

References

Figure 1. Carbon content in leaf, thin and thick branches of olive trees of the EAS Meramvellou and Pezon. Columns not associated with the same letter differ considerably according to the Tukey criterion for p≤0.05. Each column corresponds to an average of 12 metrics.
Figure 2. The content of leaves, thin and thick branches of olive trees of EAS Miramvellou and Pezon in nitrogen (A), potassium (B), calcium (C), magnesium (D), zinc (E) and manganese (F). Columns not associated with the same letter differ considerably according to the Tukey criterion for $p \leq 0.05$. Each column corresponds to an average of 12 metrics.
EFFECTS OF ADDITION OF ORGANIC MATERIALS AND IRRIGATION CONDITIONS ON SOIL QUALITY IN OLIVE GROVES: A CASE STUDY OF THE REGION OF MESSINIA, SOUTH WEST PELOPONNESE, GREECE.

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Abstract

The application of organic materials to land is a common practice in sustainable agriculture in the last years. However, its implementation in olive groves under different irrigation regimes has not been systematically tested under the prevailing Mediterranean conditions. A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The aim of this work was to study the effect of alternative carbon input techniques (i.e. wood shredded, pruning residues, returning of olive mill wastes to the field with compost) and irrigation conditions (irrigated and rainfed olive orchards) on spatial distribution of soil chemical and microbial properties in two soil depths (0-10 cm and 10-40 cm). The study took place in the region of Messinia, South western Peloponnese, Greece during three year soil campaigns. The results indicated significant changes of soil’s chemical and biological properties in olive orchards, due to carbon treatments. However, these changes were dependent on irrigation conditions. Levels of most of the soil properties were considerable higher under the canopy as compared to outside of the canopy. Proper management of alternative soil carbon inputs in olive orchards can positively affect soil fertility.

Keywords: carbon inputs, soil, chemical properties, microbial properties, olive groves, irrigation.

Introduction

Intensive cultivation practices are associated to soil degradation mainly due to low soil organic matter content. The application of organic materials to land is a common practice in sustainable agriculture in the last years. However, its implementation in olive groves under different irrigation regimes has not been systematically tested under the prevailing Mediterranean conditions. A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The aim of this work was to study the effect of alternative carbon input techniques (i.e. wood shredded,
pruning residues, returning of olive mill wastes to the field with compost) and irrigation conditions (irrigated and rainfed olive orchards) on spatial distribution of soil chemical (pH, EC, total organic carbon, total nitrogen, inorganic nitrogen, humic and fulvic acids, available P, and exchangeable K) and microbial properties (soil basal microbial respiration and microbial biomass carbon) in two soil depths (0-10 cm and 10-40 cm).

Materials and Methods

The area of study is located in the region of Messinia, South west Peloponnese Greece. Forty soil parcels of olive groves were selected. The size of soil parcels varied between 0.5-3 hectares. Carbon input practices (CT) were applied on the half of the irrigated and rainfed soil parcels (Irrigation conditions IC; 20 rainfed and 20 irrigated), while the remaining ones were used as controls. Carbon inputs were a combination of chopped pruning residues, with compost derived from recycling byproducts of a 3-phase olive mill. Weeds were also maintained and cut before spring. A soil sampling campaign took place during 2012-2016. In each soil parcel six composite soil samples were taken from 0-10 cm of depth, at equal intervals, along a straight line joining the trunk of the tree with the middle of the distance from the nearest tree of the next tree series. The first three samples were under the tree canopy. An additional composite sample was taken at the depth of 10-40 cm. Soil analysis was carried out via standard methodologies (Page et al., 1982), that analyzed soil texture, pH, EC, total organic carbon, total nitrogen, inorganic nitrogen, humic and fulvic acids, available P, exchangeable K and microbial properties (soil basal microbial respiration and microbial biomass carbon). Main soil properties are presented in Tables 1a and 1b.

Table 1 a. Main soil properties of control soil parcels

<table>
<thead>
<tr>
<th></th>
<th>Clay (%)</th>
<th>pH (°)</th>
<th>EC (mS cm⁻¹)</th>
<th>SOC (g kg⁻¹)</th>
<th>TN (g kg⁻¹)</th>
<th>NO₃⁻</th>
<th>NO₂⁻</th>
<th>NH₄⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated fields</td>
<td>Mean</td>
<td>30</td>
<td>7.05</td>
<td>1.65</td>
<td>30.81</td>
<td>1.97</td>
<td>5.6</td>
<td>48.9</td>
</tr>
<tr>
<td></td>
<td>Std. Error of Mean</td>
<td>2.66</td>
<td>0.11</td>
<td>0.11</td>
<td>1.97</td>
<td>0.14</td>
<td>0.21</td>
<td>7.02</td>
</tr>
<tr>
<td>Rainfed fields</td>
<td>Mean</td>
<td>34</td>
<td>6.70</td>
<td>1.79</td>
<td>32.25</td>
<td>2.00</td>
<td>7.8</td>
<td>48.3</td>
</tr>
<tr>
<td></td>
<td>Std. Error of Mean</td>
<td>2.61</td>
<td>0.14</td>
<td>0.12</td>
<td>1.97</td>
<td>0.10</td>
<td>0.06</td>
<td>4.03</td>
</tr>
</tbody>
</table>

(°) Electrical conductivity (EC), soil organic carbon (SOC), total nitrogen (TN), inorganic nitrogen (NO₃⁻ and NH₄⁺)

Table 1 b. Main soil properties of control soil parcels

<table>
<thead>
<tr>
<th></th>
<th>Pavail (°)</th>
<th>Kexch (°)</th>
<th>Caexch (°)</th>
<th>Mgexch (°)</th>
<th>HA (°)</th>
<th>FA (°)</th>
<th>SBMR (°)</th>
<th>MB-C (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg kg⁻¹</td>
<td>cmol kg⁻¹</td>
<td>cmol kg⁻¹</td>
<td>cmol kg⁻¹</td>
<td>mg g⁻¹</td>
<td>mg g⁻¹</td>
<td>mg C kg⁻¹</td>
<td>mg C kg⁻¹</td>
</tr>
<tr>
<td>Irrigated fields</td>
<td>Mean</td>
<td>279</td>
<td>0.70</td>
<td>23.3</td>
<td>1.9</td>
<td>4.13</td>
<td>1.51</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Std. Error of Mean</td>
<td>6.03</td>
<td>0.05</td>
<td>1.19</td>
<td>0.13</td>
<td>0.25</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Rainfed fields</td>
<td>Mean</td>
<td>38.5</td>
<td>0.67</td>
<td>21.5</td>
<td>2.1</td>
<td>3.82</td>
<td>1.43</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Std. Error of Mean</td>
<td>6.50</td>
<td>0.04</td>
<td>0.99</td>
<td>0.23</td>
<td>0.16</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(°) Available P (Pavail), exchangeable K (Kexch), exchangeable Ca (Caexch), exchangeable Mg (Mgexch), humic acids (HA), fulvic acids (FA), Soil Basal Microbial Respiration (SBMR), Microbial Biomass Carbon (MB-C).
Results and Discussion

Soil OM was significantly increased at the 3d sampling period compared to the first two while TN and BR was significantly reduced (Fig. 1). The increase of OM may be partially attributed to the relatively lower microbiological activity and therefore low rate of C mineralization (Dersch and Bohm, 2001). Moreover, no tillage practices or reduced tillage was applied to soil parcels. Many workers have reported that these practices can substantially increase carbon sequestration in soils (Álvaro-Fuentes et al., 2008).

Cultivation practices did not have a significant effect on EC, TN, OM, and microbial properties. On the other hand, available P was increased in irrigated and decreased in rainfed parcels, while available K was significantly increased in both irrigated and rainfed parcels. The improved mobility of P has been attributed to the movement of P in mass flow with irrigation waters, after the saturation of reaction sites near the zone of P application (Neilsen et al. 1997).

Irrigation conditions (IC) significantly affected the chemical and microbial properties of soils (Karyotis et al., 2014). Most of the soil parameters were significantly higher in irrigated olive groves, compared to rainfed olive groves.
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Fig 1. Effects of carbon treatments (CT), irrigation conditions (irrigated-IR and rainfed –RF parcels), and distance from the tree trunk on soil organic matter (OM), total nitrogen (TN), and Soil Basal Microbial Respiration (BR). Y1=2012-2013; Y2=2014-2015; Y3=2016-2017

Levels of most of soil's chemical and microbial properties were significantly higher under the canopy as compared to outside the canopy. The area under the tree is richer in organic residues compared to the area that lies out of the tree canopy (Soria et al. 2005). In addition, nutrients in soils out of the tree canopy are subjected to leaching due to rainfall, while the replenishment of nutrient loss is limited. Soil management practices should consider the spatial distribution of soil properties in relation to the distance of the tree trunk. With regard to changes of soil properties according to depth, significant decreases were registered for SOC, TN, inorganic nitrogen (NH$_4^+$ and NO$_3^-$), BR and MB-C.

PCA showed a strong positive influence of CT on soil fertility and quality in irrigated fields. Further statistical analysis will take place in order to determine the effect of the type of CT on soil. Soil data from the treated irrigated fields (IRT) were ordinated within the left side of the bi-plot, while the right side was occupied by soil data from rainfed-control fields (RC). Soil data from treated-rainfed (RT) and irrigated-control fields (IRC) are ordinated in the centre of the axis. The ordination of the soil data along the horizontal axis is due to the higher values, in the majority of the estimated soil properties, that the IRT presented compare to the C. The ordination of the samples indicates that the combined effect of IR and T is very strong.

Long term monitoring of soil properties in olive groves under different soil management systems will allow for a deeper understanding of carbon input practices on soil quality.

Fig 2. Ordination of soil properties and variables on a PCA (Principal Components Analysis) biplot (RC=rainfed-control fields, IRC=irrigated-control fields, IRT=irrigated-treated fields, RT=rainfed-treated fields)

Acknowledgements
Climate Changing Agriculture

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References


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EFFECTS OF ADDITION OF ORGANIC MATERIALS AND IRRIGATION CONDITIONS ON SOIL QUALITY IN OLIVE GROVES: A CASE STUDY OF IN THE REGION OF MERAMBELLO, ISLAND OF CRETE, GREECE.

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Abstract

Olive tree pruning residue and olive waste represent a great amount of organic materials which are produced during a short period. The application of organic materials to land is a common practice in sustainable agriculture in the last years. However, its implementation in olive groves under different irrigation regimes has not been systematically tested. A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The aim of this work was to study the effect of alternative carbon input techniques (wood shredded, pruning residues, returning of olive mill wastes to the field with compost) on soil chemical and microbiological properties in relation to irrigation conditions (irrigated and rainfed olive orchards). The results showed that changes of soil quality in olive orchards due to carbon inputs depend on irrigation conditions. Soil carbon, available nutrients and MB-C were not affected by the addition of organic material compared to control. However, TN was significantly reduced and BR was significantly increased by carbon inputs. Nutrient contents and microbial properties declined according to the distance from the tree, regardless the irrigation regime and carbon input treatment. Soil depth significantly influenced soil attributes. Proper management of alternative carbon inputs in soil can positively affect soil productivity in Mediterranean olive groves.

Keywords: carbon inputs, soil, chemical properties, microbial properties, olive groves, irrigation.
Olive tree pruning residue and olive waste represent a great amount of organic materials which are produced during a short period. The application of organic materials to land is a common practice in sustainable agriculture in the last years. However, its implementation in olive groves under different irrigation regimes has not been systematically tested. A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The aim of this work was to study the effect of alternative carbon input techniques (wood shredded, pruning residues, returning of olive mill wastes the field with compost) on soil chemical (pH, EC, total organic carbon, total nitrogen, inorganic nitrogen, humic and fulvic acids, available P, and exchangeable K), and microbial properties (soil basal microbial respiration and microbial biomass carbon) in relation to irrigation conditions (irrigated and rainfed olive orchards).

Materials and Methods

The area of study is located in the region of Merabello, prefecture of Lasithi, Island of Crete, South Greece. Forty soil parcels of olive groves in the region of Mirambelo, Crete, were selected. The size of soil parcels varied between 0.1-2 hectares. Carbon input practices (CT) were applied on the half of the irrigated and rainfed soil parcels (Irrigation conditions IC; 20 rainfed and 20 irrigated), while the remaining ones were used as controls. Carbon inputs were a combination of chopped pruning residues, with compost derived from recycling byproducts of an olive mill. The compost produced from mixing olive pomace, leaves, and chopped pruning residue and it was spread on soil at a rate of 10.3 t ha\(^{-1}\). Pruning residues were spread on soil at a rate of 3.9 t/ha. Weeds were also maintained and cut before spring. A soil sampling campaign took place during 2012-2016. In each soil parcel six composite soil samples were taken from 0-10 cm of depth at equal intervals, along a straight line joining the trunk of the tree with the middle of the distance from the nearest tree of the next tree series. The first three samples were under the tree canopy. An additional composite sample was taken at the depth of 10-40 cm. Soil analysis was carried out via standard methodologies (Page et al., 1982) that analyzed soil texture, pH, EC, total organic carbon, total nitrogen, inorganic nitrogen, humic and fulvic acids, available P, exchangeable K and microbial properties (soil basal microbial respiration and microbial biomass carbon). Main soil properties are presented in Tables 1a and 1b.

Table 1a. Main properties of the soil in control plots

<table>
<thead>
<tr>
<th>Distance from tree</th>
<th>Clay (%)</th>
<th>Silt (%)</th>
<th>Sand (%)</th>
<th>SP (%)</th>
<th>pH (a)</th>
<th>EC (a) mS cm(^{-1})</th>
<th>SOC (a) mg g(^{-1})</th>
<th>TN (a) mg g(^{-1})</th>
<th>NH(_4) (a) mg kg(^{-1})</th>
<th>NO(_3) (a) mg kg(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35±4.1</td>
<td>27±2.4</td>
<td>38±3.9</td>
<td>53±1.3</td>
<td>6.50±0.34</td>
<td>1.74±0.32</td>
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<td>3.00±0.15</td>
<td>1.84±0.15</td>
<td>43.17±16.08</td>
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<td>33.9±2.7</td>
<td>2.55±0.17</td>
<td>5.23±2.09</td>
<td>10.99±2.89</td>
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</table>
from tree Distance (Henr and Hogg, 2003).

influenced nutrient availability compared to rainfed fields, promoting therefore soil fertility.

higher in irrigated fields. Favorable soil water conditions in irrigated fields positively influenced nutrient availability compared to rainfed fields, promoting therefore soil fertility. Irrigation conditions (IC) significantly affected the chemical and microbial properties of soils (Henr and Hogg, 2003).

### Results and Discussion

Soil OM was significantly increased at the third sampling period compared to the first two while TN and BR was significantly reduced (Fig. 1). The increase of OM may be partially attributed to the relatively lower microbiological activity and therefore low rate of C mineralization (Dersch and Bohm, 2001). Moreover, no tillage practices or reduced tillage were applied to soil parcels. Many workers have reported that these practices can substantially increase carbon sequestration in soils (Álvaro-Fuentes et al., 2008).

Overall the sampling periods and irrigation conditions, alternative cultivation practices (CI) did not affected the soil OM, available nutrients and MB-C compared to controls. However, TN was significantly reduced and BR was significantly increased by organic addition indicating enhanced N mineralization due to organic additions. The above effects were also related to HA/FA ratios. On the other hand, PCA showed a strong positive influence of CP on soil fertility and quality. Principal Component Analysis (Fig. 2) showed that soil data from the irrigated-treated fields (IRT) and rainfed-treated fields (RT) were ordinated within the left side of the x Axis, while the right side was occupied by samples from rainfed-control fields (RC), irrigated-control fields (IRC). The ordination of the data along the horizontal axis is due to the higher values, that the CI both in irrigated and rainfed fields presented compare to the controls.

Organic matter accumulation in surface layer was higher in rainfed fields compared to irrigated ones mainly attributed to low decomposition rates indicated by the microbial properties. On the other hand available nutrients TN and microbiological parameters were higher in irrigated fields. Favorable soil water conditions in irrigated fields positively influenced nutrient availability compared to rainfed fields, promoting therefore soil fertility.
The levels of most of soil's chemical and microbial properties were significantly higher under the canopy, as compared to outside the canopy. The area under the tree is richer in organic residues compared to the area that lies out of the tree canopy (Soria et al. 2005). In addition, nutrients in soils out of the tree canopy are subject to leaching due to rainfall, while the replenishment of nutrient loss is limited. Soil management practices should consider the spatial distribution of soil properties in relation to the distance from the tree trunk. In addition, most of soil parameters were significantly decreased with soil depth, indicating the high potential of surface soil to sequester carbon and nutrients in olive groves.

Fig. 2. Ordination of soil properties and variables on a PCA (Principal Components Analysis) biplot (RC=rainfed-control fields, IRC=irrigated-control fields, IRT=irrigated-treated fields, RT = rainfed-treated fields)
Fig 1. Effects of carbon treatments (CT), irrigation conditions (irrigated and rainfed parcels), and distance from the tree trunk on soil organic matter (OM), total nitrogen (TN), and Soil Basal Microbial Respiration (BR). \( Y1=2012-2013; Y2=2014-2015; Y3=2016-2017 \)

Acknowledgements

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EFFECTS OF ADDITION OF ORGANIC MATERIALS AND IRRIGATION CONDITIONS ON SOIL QUALITY IN OLIVE GROVES: A CASE STUDY OF THE REGION OF PEZA, ISLAND OF CRETE, GREECE

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Abstract

A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The aim of this work was to determine the effects of organic inputs and irrigation conditions on some of soil's chemical and microbial properties, in Mediterranean olive orchards. This study also examined the spatial distribution of soil properties in relation to the distance from the tree trunk. The results showed that no tillage practices or reduced tillage can substantially increase carbon sequestration in soils. The effect of addition of organic matter was dependent on irrigation conditions. Alternative cultivation practices significantly reduced OM and nutrients (Total N, available P and K) in rainfed fields without any substantial effect in irrigated fields. Olive trees can increase soil carbon content especially close to the olive tree trunks. Furthermore, significant decreases with soil depth were registered for most soil properties, indicating that in olive groves, the potential of surface soil to sequester carbon and nutrients is high.

Keywords: carbon inputs, soil, chemical properties, microbial properties, olive groves, irrigation.

Introduction

Optimizing carbon balance in olive groves may improve soil fertility and biodiversity and contribute to climate change mitigation, since carbon is removed from the atmosphere. During olive growth, a large quantity of plant residues are produced while high loads of both liquid and solid olive mill wastes are produced during the extraction of olive oil. Montanaro
et al. (2012) reported that when long term recycling of plant residues is combined with application of compost in soil in Mediterranean tree crops, then the organic matter is substantially increased. The implementation of these techniques has not been systematically tested under the prevailing conditions of the Greek/Mediterranean olive forest. A LIFE+ project was initiated (oLIVE-CLIMA; LIFE 11/ENV/000942) aiming to introduce alternative management practices in olive tree crops. The study area was located in the region of Peza, Island of Crete and the aim of this work was to determine the effects of organic inputs and irrigation conditions on some of soil’s chemical and microbial properties, in relation to soil depth and the distance from the olive tree trunk.

Materials and Methods

Forty soil parcels of olive groves were selected. The size of soil parcels varied between 0.5-4 hectares. Carbon input practices (CT) were applied on the half of the irrigated and rainfed soil parcels (Irrigation conditions IC; 20 rainfed and 20 irrigated fields), while the remaining ones were used as controls. Carbon inputs were a combination of chopped pruning residues, with compost derived from recycling byproducts of a 3-phase olive mill. The compost was supplied once at a rate of 1.8 t ha\(^{-1}\) and soil was supplemented with chopped pruning residues from the same groves (f.w. 6.9 t ha\(^{-1}\)). Weeds were also maintained and cut before spring. A soil sampling campaign took place during years 2012-2013 and 2014-2015. In each soil parcel six composite soil samples were taken from 0-10 cm of depth, at equal intervals, along a straight line joining the trunk of the tree with the middle of the distance from the nearest tree of the next tree series. The first three samples were under the tree canopy. An additional composite sample was taken at the depth of 10-40 cm. Soil analysis was carried out via standard methodologies (Page et al., 1982) and the samples were analyzed for soil texture, pH, EC, total organic carbon, total nitrogen, inorganic nitrogen, humic and fulvic acids, available P, exchangeable K, soil basal microbial respiration (BR) and microbial biomass carbon (MB-C). Main soil properties are presented in Table 1.

Table 1. Main soil properties \(^{(1)}\) in control soil parcels

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.40</td>
<td>8.10</td>
<td>7.43</td>
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<tr>
<td>EC</td>
<td>0.20</td>
<td>4.93</td>
<td>1.99</td>
<td>0.12</td>
</tr>
<tr>
<td>CaCO(_3)</td>
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<td>54.60</td>
<td>31.13</td>
<td>1.64</td>
</tr>
<tr>
<td>TN</td>
<td>0.57</td>
<td>2.90</td>
<td>1.85</td>
<td>0.08</td>
</tr>
<tr>
<td>TOC</td>
<td>0.94</td>
<td>40.52</td>
<td>17.29</td>
<td>0.74</td>
</tr>
<tr>
<td>P-Olsen</td>
<td>4.03</td>
<td>156.00</td>
<td>56.01</td>
<td>1.77</td>
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<tr>
<td>K(_{exch})</td>
<td>0.11</td>
<td>2.60</td>
<td>0.88</td>
<td>0.03</td>
</tr>
<tr>
<td>Ca(_{exch})</td>
<td>8.60</td>
<td>76.60</td>
<td>27.52</td>
<td>0.72</td>
</tr>
<tr>
<td>Mg(_{exch})</td>
<td>0.37</td>
<td>6.80</td>
<td>2.18</td>
<td>0.07</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Electrical conductivity (EC, mS/cm), Total organic carbon (TOC, mg kg\(^{-1}\)), total nitrogen (TN, mg g\(^{-1}\)), available P (Pavail, mg kg\(^{-1}\)) , exchangeable K (K\(_{exch}\), cmol kg\(^{-1}\)) , exchangeable Ca (Ca\(_{exch}\), cmol kg\(^{-1}\)) , exchangeable Mg (Mg\(_{exch}\), cmol kg\(^{-1}\))
Soil organic matter (SOM) and BR were significantly increased at the second sampling period compared to the first one, while Kexc, Pavail, and HA/FA were significantly reduced (Fig. 1). The increase of OM, followed by decreases in nutrient availability, may be partially attributed to relatively lower humification rates indicated by the HA/FA ratio (Stevenson, 1994). Moreover, long term no-tillage and/or reduced tillage practices have been applied to soil parcels in the region. Many workers reported that these practices can substantially increase carbon sequestration in soils (Álvaro-Fuentes et al., 2008). The effect of organic matter addition (CT) was dependent on irrigation conditions. Alternative cultivation practices significantly reduced OM and nutrient availability (TN, Kexc and P avail) in rainfed fields, while no substantial effect was recorded in irrigated fields. Different sources of organic matter have different assimilation and decomposition characteristics, and result in different soil organic matter fractions. If the rate of assimilation is less than the rate of decomposition, soil organic matter will decline. On the other hand in irrigated fields, CT significantly increased HA/FA and BR, which was attributed to favorable soil moisture conditions. Irrigation conditions (IC) significantly affected the chemical and microbial properties of soil (Henr and Hogg, 2003). Favorable soil water conditions in irrigated fields positively influenced nutrient availability, organic matter accumulation and microbiological activity on surface soil compared to rainfed fields, promoting
Fig 1. Effects of carbon treatments (CT), irrigation conditions (irrigated-IR and rainfed –RF parcels), and distance from the tree trunk on exchangeable K (K<sub>exch</sub>), avail P (P avail.), humic-acid-fulvic acid ratio (HA/FA), soil organic matter (OM),
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total nitrogen (TN), and Soil Basal Microbial Respiration (BR). $Y_1=2012-2013$; $Y_2=2014-2015$.

therefore soil-fertility. The levels of many soil chemical and microbiological properties were significantly higher under the canopy as compared to outside of the canopy, indicating that olive trees promote soil quality closer to the tree trunk. Soil management practices should consider the spatial distribution of soil properties. With regards to the changes of soil properties according to depth, significant decreases were registered for SOM, TN, available nutrients and microbiological properties. The reduced microbiological activity with soil depth affected plant residues decomposition rates (Wendling et al., 2010).

Principal Component Analysis showed that control plots had higher soil values compared to treated fields with organic materials (Fig 2). Soil parameters in control parcels and mostly in irrigated fields were ordinated within the left side of the first axis (Factor 1) compared to rainfed fields treated with organic materials which was ordinate at the right side. Along the second axis, (Factor 2) soil data from treated fields were classified together at the lower part while control soil data were ordinated towards the upper part of the axis. It is concluded that long term monitoring of soil properties in olive groves under different soil management systems will allow for the achievement of a deeper understanding of carbon input practices on soil fertility and productivity.

Acknowledgements

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Abstract

Olive trees constitute one of the most dynamic cultivations for Mediterranean countries, while their economic importance is high. Due to the fact that water constitutes a fundamental factor affecting olive trees production, soil water content is one of the most critical parameters that has to be monitored in order to improve olive trees cultivation management. With this in mind, soil water content was systematically monitored at various depths in a Mediterranean area (Trifilia, south Greece) for the period 2014-2016 in order to identify seasonal variation patterns and implications. The results demonstrate that soil water content and fruit yield variation was significant both for rainfed and irrigated fields, mainly because of complex interference of several factors that contribute to this variation such as soil texture, tree size and leaf area, weed cover, overall tree health and nutrition. Moreover, the period August-September was found to be more significantly affecting final fruit yield. The potential to improve irrigation practices in the area was also indicated by the results.

Introduction

The value of olive trees cultivation is of high importance for the Mediterranean basin both from the economic and the ecological perspective (Loumou & Giourga 2003). More than 70% of olive trees around the world are cultivated in European Union’s (EU) Mediterranean countries (Greece, Italy, Portugal and Spain) (Carmasa et al. 2010) and therefore, EU constitutes globally the major olive oil producer. Greece holds about 9% of the EU olives production, while olive products are of high significance for the national economy. Olive oil and table olives produced in Greece, not only serve the domestic needs, but a significant volume of olive oil exported inside and outside of EU.

Despite the fact that olive trees have limited water requirements and can grow in shallow, of low fertility and high salt content soils, the intensification of their cultivation combined to climate variability and increased cultivation costs are causing strong pressures on olive cultivation in Greece. Although favorable for olive trees cultivation, Mediterranean climate conditions are characterized by limited water availability which according to Fereres et al. (2003), reduces the potential to increase irrigated areas in olive industry, taking into account also the competitive non-agricultural uses.

Taking into account the above, the present paper aims to analyze soil water content variation in 12 Mediterranean olive groves and demonstrate how to reveal significant outcomes about: a) the relation of soil water content with olive fruit yield during 4
bimonthly periods and b) the differences in soil water content and olive fruit yield between of irrigated and rainfed olive groves.

Materials and Methods
This study was implemented in Trifilia which is located in south west Peloponnese (Greece) and characterized by wet Mediterranean climate (Csa). Six rainfed and six irrigated olive fields were chosen in order to systematically monitor soil water content at monthly intervals for the period 2014-2016. The trees in every field were mature (20-50 years old) and drip irrigation was applied to the irrigated fields. Soil water content monitoring was performed with PR2 sensors produced by DELTA-T Devices Ltd., accompanied by a HH2 readout unit. For the purposes of our study, three access tubes were installed in each monitored field and soil water content was measured at 4 depths, namely at 10, 20, 30 and 40 cm. Slope of the fields was 0-6% and the three access tubes in each monitoring field were installed under the canopy of trees, at 3/4 of the canopy radius from the trunk and at representative points of the field in terms of crop growth. Four bimonthly periods were identified for results representation and analysis, namely February-March (period 1), April-May (period 2), June-July (period 3) and August-September (period 4).

Results and Discussion
Soil water content variation on the 6 rainfed fields during the four bimonthly periods of years 2014-2016 is presented in Fig. 1. The variation of crop production is also illustrated. With regard to the first period (February-March) median soil water content varied between 36.78 (2016) and 40.02% (2015). Concerning the 2nd period (April-May), higher median soil water content values were observed for year 2016 (36%) followed by year 2015 (34.98%) and year 2014 (29.38%). During the 3rd period (June-July) higher soil water contents were observed for year 2016 compared to year 2014 but the median soil water content for the two year is very close. Finally, with regard to the 4th period (August-September), median soil water content was found to be much higher on year 2016 (18.58%) followed by year 2015 (13.83%) and year 2014 (12.71%).

Since the corresponding plots are rainfed, the variability indicated in soil water content variation is directly connected to precipitation variability during the two-month periods. The high soil water content variation range observed during wet period demonstrate the diversion of soil hydraulic behavior, trees distribution and possibly cultivation practices within the rainfed fields. There is no specific trend identified between soil water content during the wetter periods (periods 1 and 2) and the drier period (periods 3 and 4). When comparing in-periods soil water content to the corresponding olive fruit yields, the highest correlation is observed for Aug-Sep period, while a similar trend is also observed for period April-May. It is interesting to mention that the highest median soil water contents were indicated for periods 2-4 during year 2016. This fact indicate higher water availability and less water stress throughout almost the whole growing period (April to September) which resulted to the highest olive fruit yields recorded during the period 2014-2016, thus indicating the significance of soil water availability in order to maintain higher olive fruit yields.

The corresponding variation of soil water content on the 6 irrigated fields during the four period of the years 2014-2016 is presented in Fig. 2, accompanied by the a crop production boxplot. With regard to the first period (February-March) median soil
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water content varied between 35.74 (2014) and 40.21% (2015). Concerning the second period (April-May), higher median soil water content values were observed for year 2016 (36.77%) followed by year 2015 (32.57%) and year 2014 (31.31%). During the 3rd period (June-July) higher soil water contents were observed for year 2014 (23.24%) compared to year 2016 (22.12%) but the median soil water content for the two year is very close. Finally, with regard to the 4th period (August-September), median soil water content was found to be much higher on year 2016 (21.44%) followed by year 2014 (17.12%) and year 2015 (16.55%).

Fig.1. Boxplots of soil water content variation on the 6 rainfed fields for the periods February-March (a), April-May (b), June-July (c) and August-September (d), and crop production variation at the end of each cultivation period (e).
Soil water content variation pattern for periods 1 and 2 in irrigated fields is similar to the corresponding pattern for rainfed fields. This result indicates that the influence of precipitation variation is similar for rainfed and irrigated fields. The fact that interquartile range of soil water content variation for irrigated fields during the 4 periods is much wider compared to the corresponding range for rainfed fields indicates potential variability in irrigation application. Similarly to the rainfed fields, there is no specific trend identified between soil water content during the wet period (periods 1 and 2) and the dry period (periods 3 and 4). When comparing in-period soil water content to the corresponding olive fruit yields, a similar variation trend is observed for Aug-Sep period, while a similar trend is also observed for period April-May. Due to the fact that the same results were identified for rainfed plots too, it can be concluded that during the monitoring period (2014-2016), soil water content during the period Aug-Sep is more critical for the final crop production. This period is included in olive accumulation period during which water stress leads to reduction of oil percentage on a dry weight basis at harvest (Steduto et al. 2012).

Conclusions

Soil water content monitoring was systematically performed in 12 olive fields (6 irrigated and 6 rainfed) located in southwestern Greece in order to investigate temporal variation patterns, identify relations between soil water content and olive fruit yield variation and finally to explore potential differences in the above patterns between rainfed and irrigated fields.

The results demonstrate that soil water content and fruit yield variation was significant both for rainfed and irrigated fields, mainly because of complex interference of several factors that contribute to this variation such as soil texture, tree
size and leaf area, weed cover, overall tree health and nutrition. Despite this complex interference which makes the identification of relationship between olive fruit yields and soil water content a very tricky task, some significant outcomes were revealed. Due to the similarity between fruit yield and soil water content variation during the period August-September, it is indicated that soil water content variation during this period (corresponding to oil accumulation) is more significantly affecting final olive fruit yield. Moreover, the fact that median fruit yield of irrigated fields was very close to the corresponding value for rainfed fields demonstrate a significant potential for irrigation scheduling improvement in order to save irrigation water during period for which soil water availability is sufficient to maintain satisfactory olive fruit yields.

Acknowledgements
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References
Abstract

Agriculture and changes in soil management systems represent a source of the three most important greenhouse gas emissions (GHG); carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$). The soil management system contributes to over 25% of global anthropogenic greenhouse gas emissions, between 10 and 14% comes directly from production processes and 12%-17% by changes in the soil surface thanks to the use of groundcovers. Agriculture is currently responsible for 13.5% of global GHG emissions, being the 4th sector involved in global warming.

One way to study the influence of tillage on carbon soil emissions is to measure the $CO_2$ flux from the soil surface which allows us to quantify the agricultural activities as favourable or unfavourable factors to the soil carbon fixation. Therefore, we did a research in which we compared the total $CO_2$ emission volumes in soils under no tillage with others under traditional tillage. The measurements have been carried out at Rabanales farm located in Córdoba (southern Spain).

In this study we have also measured the soil organic carbon (SOC) sequestration potential under the two management systems. The results show an average content of this element which is 16% higher in the no till plots than in the traditional tilled ones.

Keywords: Climate change, Conservation Agriculture, $CO_2$ emission, Carbon sequestration

Introduction

In a world in which the concern for food security is increasing, there are important questions to be addressed about the impact of climate change on the production and availability of food (Beddington et al., 2012; FAO, 2009).

$CO_2$ is stored in the soil pores in which an exchange flux between soil and atmosphere exists due to different concentration gradients. These fluxes can be changed by the agricultural management practices and climatic conditions. Historically, the intensive tillage of the agricultural soils has provoked substantial losses of the organic carbon (OC) content in the soil (30%-50%). The harvest residues are buried and the soil is in optimum conditions to produce $CO_2$ losses.

The adoption of Conservation Agriculture (CA), in which no-till (NT), permanent soil mulch cover and diversified cropping system are the three underpinning ecological pillars, has significant environmental benefits (Kassam et al., 2012). At the same time, NT systems are acknowledged for being more profitable for farmers (e.g., González-Sánchez, et al., 2015).

One way to study the influence of tillage in the carbon soil emission is to measure the $CO_2$ flux from the soil surface which will allow us to quantify the agricultural activities as favourable factors or not to the soil carbon fixation. With this aim, a study has been made in which we have compared the total $CO_2$ emission volumes in soils under no tillage with others under traditional tillage. The measurements have been made in a field located in Córdoba (south Spain).
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The emission measurements were made monthly over two seasons (2015/16 and 2016/17), with an infrared portable EGM-4 absolute and differential gas analyser, coupled with a soil respiration chamber. The respiration chamber was approximately 15 cm high, and had a diameter of 10 cm with a CO$_2$ flow measurement capacity ranging between 0 and 9.99 g CO$_2$ m$^{-2}$ h$^{-1}$. The measurement precision was ± 1SD (standard deviation), with a resolution of 1 ppm.

Also, to evaluate the temporal evolution of the SOC content in the two systems, soil samples were extracted monthly with an Eihmeyer tube and transported to the laboratory. Total SOC content was determined using the Walkley-Black method (Nelson and Sommer, 1982).

Results and Discussion

Figure 1 shows in all cases, the CO$_2$ emission increases due to the rupture of the soil aggregates by the different labours made in the tillage plots, bed seeding and sowing.

This gas flux emitted to the atmosphere is released along a time period between the tillage labour and 24 hours, reaching the maximum normally four hours after the tillage. The last measurement is taken 24 hours later when the emission regime returns to the normal value.
The difference in the quantity of emitted gas due to the mechanical alteration of soil by tillage operations between the two systems shows up to 139.5 kg of CO$_2$ more in the plots under traditional tillage than in the No-till ones in a day.

This value extrapolated to the great agricultural areas shows the great mitigating potential of the No-till systems.

If no till management practices had been used on the total of the maize surface cultivated in 2015/16 season, 4858 tonnes of CO$_2$ would not have been emitted into the atmosphere.

In this study we have also measured the soil organic carbon sequestration potential under the two management systems. The results show an average content of this element which is 12% in the season 2015/16 and 16% in the 2016/17 season higher in the no till plots than in the traditional tilled ones.

Figure 2 represents the SOC data obtained in the 5 cm top soil. In this depth interval the main physical, chemical and biological changes are produced therefore the SOC increment content are observed in a shorter period. The soil in the no-till system shows higher SOC content than the conventional one.
Figure 3 shows the SOC increases in the two management systems. However, these increases are not linear and the graphs present many fluctuations along the different samplings. This owes to the high relation among the SOC content and the climatic conditions at the moment of the sampling.

The weather modifies the nature of plant residue decomposition, the moisture and the temperature are the most important and determining variables. They condition the vegetative development and the microorganism activities, critical factors in soil formation.

In all cases it can be observed how the no-till plots present a SOC average about 12% and 16% higher respectively for the two growing seasons studied.

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Abstract

Olive trees have been traditionally cultivated in shadow soils located on hills which have been gradually degraded due to erosion favoured by intensive tillage. Cover crops (CC), sown or spontaneous, in the inter-row of olive trees have proven to be an efficient practice to reduce soil and nutrient losses acting as a sink of atmospheric carbon and improving soil fertility.

The aim of this study has been to assess the CO$_2$ sequestration potential of several species used as CC in two olive orchards.

The experiment was conducted during three growing seasons in two olive orchards from Andalusia (Spain). In the experimental field 1, a grass (*Brachypodium distachyon*) and two crucifers (*Eruca vesicaria* and *Sinapis alba*) were sown and compared to the spontaneous vegetation of the area (Spon1). In the other experimental field, three legumes, usually used as CC, were sown: common vetch (*Vicia sativa*), bitter vetch (*Vicia ervilia*) and hairy vetch (*Vicia villosa*). The decomposition and carbon release from cover crops were studied and soil organic carbon (SOC) analyzed during the decomposition period to assess the atmospheric fixation.

The increments of SOC in the first 20 cm in depth reached higher values with crucifers and the grass than legumes, mainly due to the more extensive root system. *Sinapis alba* obtained the best result with 2.56 Mg SOC ha$^{-1}$ yr$^{-1}$. Although legumes improved the soil nitrogen, higher carbon sequestration was obtained with gramineous and cruciferous species.

CC are an efficient tool for atmospheric carbon sequestration and protecting the soil from erosion.

Keywords: Olive orchard, cover crops, grasses, crucifers, legumes

Introduction

Olive trees have been traditionally cultivated in shadow soils located on hills (Semple 1931). These soils have been gradually degraded due to erosion, which is favoured by some practices like the intensive tillage, furthermore, soil organic matter is decreased by erosive processes (Martínez-Mena et al. 2008). CC, sown or spontaneous, in the inter-row of olive trees have proven to be an efficient practice to reduce soil and nutrient losses (Gómez et al. 2009; Ordóñez-Fernández et al. 2007) while acting as a sink of atmospheric carbon and improving soil fertility. Thus, this conservative practice improves SOC by atmospheric fixation and reduction of tillage that increases the carbon emissions due to the rupture of the soil aggregates by the different labours (Márquez-García et al. 2013; Repullo et al. 2012a).

Most of researches compare soil management systems but few works make a comparison between different CC species belonging to different plant families. The aim of this study has been to assess the CO$_2$ sequestration potential of several species used as CC in two olive orchards.

Materials and Methods

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The experiment was conducted during three growing seasons in two olive orchards from Andalusia (Spain), the most important area of olive cultivation in the world. In the experimental field 1, a gramineous (Brachypodium distachyon) and two cruciferous (Eruca vesicaria and Sinapis alba) were sown and compared to the spontaneous vegetation of the area (Spon1), mainly composed by mallows, Convolvulus arvensis, Diplotaxis virgata, Lolium rigidum and Taraxacum officinale. In the other experimental field, three leguminous, usually used as CC, were sown: common vetch (Vicia sativa), bitter vetch (Vicia ervilia) and hairy vetch (Vicia villosa). They were studied and compared with vegetation that grew naturally in the field (Spon2), Medicago polymorpha, Bromus sp, Diplotaxis virgata, Hordeum leporinum and Anagallis arvensis were identified as the most abundant species.

The decomposition and carbon release of CC after the mechanical mowing were studied through residue samples from a 0.25 m$^2$ and the analysis of carbon content. At the beginning and the end of the decomposition period, soil samples were taken at 20 cm depth and carbon analyzed to assess the atmospheric fixation. CO$_2$ sequestration was determined from the values of SOC increments using the molecular weight ratio (1 g C = 3.67 g CO$_2$).

Results and Discussion

The carbon release in the decomposition period was variable depending on meteorological conditions each year. The averages for the three-year study period were: 1.56 Mg C ha$^{-1}$ for B. distachyon, 1.07 with E. vesicaria, 0.81 S. alba and 0.82 Spon1 in field 1. Carbon released from root system was not considered. In the field 2 the averages of carbon release with legumes at decomposition period were 1.75 with V. sativa, 1.05 for V. ervilia, 2.81 in V. villosa and 0.47 Mg C ha$^{-1}$ yr$^{-1}$ with Spon1.

This C input to soil led to improve the SOC at 20 cm depth (Table 1). The annual averages of C fixation were 1.42 Mg SOC ha$^{-1}$ yr$^{-1}$ for B. distachyon, 1.17 with E. vesicaria, 2.56 S. alba and 1.36 Spon1 in field 1. The legumes in field 2 reached lower values: 0.56 with V. sativa, 0.04 with V. ervilia and 0.70 Mg SOC ha$^{-1}$ yr$^{-1}$ in V. villosa. There was no fixation with Spon2.

The annual amount of CO$_2$ fixed ranged between 4.3 and 9.4 in field 1 (Table 1). In the field 2, the initial SOC was higher due to the soil was managed without tillage before the experiment started. The SOC increments and the fixation rates were lower in this field since increasing the SOC is more difficult with a high initial C content. Ingram and Fernandes (2001) reported that the rise in SOC declined with the time as the soil approached a new state of equilibrium. In addition, the root system of legumes is smaller than in crucifers and grasses (Alcántara et al. 2009; Ola et al. 2015).

Table 1. SOC (Mg ha$^{-1}$) increased in the first 20 cm of soil during 3 growing seasons, annual increment average and annual CO$_2$ fixation

<table>
<thead>
<tr>
<th>Field</th>
<th>Specie</th>
<th>SOC year 1</th>
<th>SOC year 3</th>
<th>Δ SOC</th>
<th>Δ annual SOC</th>
<th>Annual fixed CO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B. distachyon</td>
<td>12.37</td>
<td>16.65</td>
<td>4.28</td>
<td>1.43</td>
<td>5.23</td>
</tr>
<tr>
<td></td>
<td>E. vesicaria</td>
<td>13.01</td>
<td>16.54</td>
<td>3.52</td>
<td>1.17</td>
<td>4.31</td>
</tr>
<tr>
<td></td>
<td>Sinapis alba</td>
<td>13.10</td>
<td>20.79</td>
<td>7.69</td>
<td>2.56</td>
<td>9.40</td>
</tr>
<tr>
<td></td>
<td>Spon1</td>
<td>12.80</td>
<td>16.87</td>
<td>4.07</td>
<td>1.36</td>
<td>4.98</td>
</tr>
<tr>
<td>2</td>
<td>V. sativa</td>
<td>20.00</td>
<td>21.67</td>
<td>1.67</td>
<td>0.56</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td>V. ervilia</td>
<td>22.41</td>
<td>22.53</td>
<td>0.12</td>
<td>0.04</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>V. villosa</td>
<td>22.67</td>
<td>24.77</td>
<td>2.10</td>
<td>0.70</td>
<td>2.57</td>
</tr>
<tr>
<td></td>
<td>Spon2</td>
<td>22.35</td>
<td>17.45</td>
<td>-4.90</td>
<td>-1.63</td>
<td>-5.99</td>
</tr>
</tbody>
</table>
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The results indicated that root system had great influence in the increment of SOC, mainly with crucifers due to their tap root (Wolfe 2000). Although legumes improved the soil nitrogen, higher carbon sequestration was obtained with the gramineous and cruciferous species.

Our data are according to Smith et al. (2000) that estimated a carbon sequestration of 0.7 Mg C ha
\(^{-1}\) yr
\(^{-1}\) with crop residues and 0.4 Mg C ha
\(^{-1}\) yr
\(^{-1}\) with no tillage. Hutchinson et al. (2007) obtained average rate of potential C gain from 0.1 to 0.5 Mg ha
\(^{-1}\) yr
\(^{-1}\) with no-till system in herbaceous cropping systems.

Higher data were obtained by Nieto et al. (2013) who indicated an average increase of 4 Mg ha
\(^{-1}\) in the first year of a research carried out in three experimental fields comparing CC of weeds and tillage in olive grove. Márquez-García et al. (2013) obtained a fixation of 12.3 Mg CO
\(_2\) ha
\(^{-1}\) yr
\(^{-1}\) in five different olive orchards, which means 3.35 Mg of SOC comparing CC with tillage systems. Nevertheless, González-Sánchez et al. (2012) in a meta-analysis of carbon capture through the use of conservation agriculture in Spain reported a C coefficient of 1.59 Mg C ha
\(^{-1}\) yr
\(^{-1}\) for CC used in woody crops instead of tillage, which is according to our results. In a 7-year experiment carried out by Gómez et al. (2009b), CC doubled SOC with respect to tillage in the first 10 cm of soil. Castro et al. (2008) in a long term study obtained a SOC increment of 0.69 Mg C ha
\(^{-1}\) yr
\(^{-1}\) (0-30 cm) with use of CC comparing to bare soil controlled by pre-emergence herbicides. They found higher SOC rates when plant residues were incorporated by a pass of disk harrow which accelerated the decomposition process.

Higher SOC values may be reached with pruning residues mulching as was reported by Repullo et al. (2012b) who measured SOC increment ranged between 4.6 and 8.2 Mg C ha
\(^{-1}\) yr
\(^{-1}\) in the first 20 cm of soil with different pruning residues doses in a 2-year study. Nieto et al. (2010) observed how the SOC in olive grove increased in the first 30 cm of soil from 27.1 Mg ha
\(^{-1}\) to 113.6 Mg ha
\(^{-1}\) in a calcic vertisol and from 26.4 to 158 in a chonic calcisol as result of changes in the soil management from tillage to pruning residues application for a period of 6 and 10 years respectively. Thus, they observed an increase of 14.4 and 13.2 Mg ha
\(^{-1}\) in one year. Using pruning residues as mulching involves a higher amount of biomass and C input than in our case where herbaceous plants were used to cover the soil surface.

Using CC is an efficient tool for atmospheric carbon sequestration and protecting the soil from erosion. The election of species with greater biomass in the shoot and root system usually increases the C input and the SOC.

Acknowledgements

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References

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MODELLING SOLUTIONS FOR IMPROVED AND RESILIENT MANAGEMENT STRATEGIES FOR OLIVE TREE AGAINST FUTURE CLIMATE CHANGE

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Abstract
Olive is one of the most important tree crops in the Mediterranean basin. This crop besides providing fundamental ecosystem services, olive plays also a key role in in the rural economy. Given the large variability of olive cultivation systems (agro-forestry stands, traditional groves and new intensive and super-intensive orchards), to know in advance the response of this system under different management and climate conditions may be useful for developing strategies aimed at increasing the potentiality of this cultivation over the Mediterranean basin. In this perspective, OLIVE-MIRACLE FACCE SURPLUS project aims to provide model-based tools to identify and test adaptation/mitigation agromanagement strategies to support long-term decision making on olive-tree cultivation across the Mediterranean basin.

Keywords
Olive tree, modelling, adaptation, Mediterranean basin

Introduction
Olive is one of the most important tree cultivation in the Mediterranean basin. This crop dominates not only the rural landscape of the several countries placed around the basin, thus providing fundamental ecosystem services in large dry land areas, but it also plays a key role for their economy. Olive farming and the associate industry is highly relevant in Europe since almost 75% out of more than 3Mt of olive oil produced in the world comes from the EC. With more than 700 million trees cultivated over 9 Mha (Vossen, 2007), olive is the first tree crop in Europe. Given the large variability of olive cultivation systems (agro-forestry stands, traditional groves and new intensive and hedgerow orchards), the advanced assessment of the response of this system under different management and climate conditions may be useful for developing strategies aimed at increasing the potentiality of this cultivation over the
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Mediterranean basin. Furthermore, the large area where this crop is cultivated is widely recognized as a climate hotspot. The current estimates of climate change are expected to lead considerable changes in mean and extreme climate of this area, thus producing a large impact on olive farming profitability and geographical distribution over many regions, which may become unsuitable for its cultivation due to the joint effect of higher temperatures and lower precipitation. In this perspective, simulation models can be considered appropriate methods of analysis of future farming scenarios thanks to their ability to provide information at larger scale and under different conditions (i.e. climate, soil and management). The use of simulation models can indeed bring several advantages in planning aspects like (i) the improvement of management strategies; (i) the harmonization between farmers’ and sustainable ecosystems objectives, coupling olive tree cultivation profitability with the capacity of providing environmental services; (iii) the release of modelling solutions to assess climate change impact on olive farming systems in Mediterranean environments and to support the development of sustainable and resilient agro-management strategies.

On these basis, OLIVE-MIRACLE (a FACCE SURPLUS financed project) aims at providing tools to identify and test the effectiveness of adaptation/mitigation management strategies to support long-term investment decision making on olive-tree cultivation across the Mediterranean under current and future climate.

Rationale

The project is built upon a consolidated consortium of four research institutes from Spain (University of Cordoba), Italy (National Research Council and Council for Agricultural Research and Economics), Cyprus (Agricultural Research Institute) and Greece (Hellenic Agricultural Organization DEMETER), having long-lasting and solid collaborations with farmer’s networks across the Mediterranean.

In order to assess climate change impacts on olive farming systems and to identify sustainable and resilient agronomic strategies, OLIVE-MIRACLE is grounded upon the use of modelling solutions. In the specific, Work Package (WP) 2 (Fig. 1) is devoted to calibrate and apply the OLIVECAN growth and development simulation model, developed at the University of Cordoba and IAS-CSIC. OLIVECAN incorporates a sub-model of water balance which simulates soil evaporation, tree transpiration and surface runoff. Photosynthesis, respiration, biomass accumulation and partitioning fruit and oil production as well as olive phenology dates are also simulated by OLIVECAN. An new, recently developed version of OLIVECAN includes the effects of a) advanced and detailed simulation of photosynthesis and carbon assimilation; b) simulation of oil accumulation using thermal time approach; c) simulation of the soil-plant-atmosphere continuum with explicit account of soil, root and shoot hydraulic resistance (thus the effect of water stress on photosynthesis and growth) and d) the response of stomatal conductance to leaf water potential; and e) the effect of extremes temperatures and water stress peaks on flowering and yield formation.

During the project, the model will also be improved by incorporating newly developed modules to simulate previously uncovered topics, such as interactions with pest/diseases and the dynamics of some quality traits. Since OLIVECAN does not explicitly account for yield quality, a statistical model will be developed for exploring causal relationships between environmental factors and quality-parameters. The resulting modelling solutions will be implemented into the BioMA platform, currently
used by the European Commission, which is designed upon component-oriented principles to allow model integration and reusability. To be of any practical relevance, the study should be conducted at high spatial resolution, therefore, part of the activity will be focused on the collection of spatial data at high resolution (10 km).

Once the model has been calibrated, a range of case-studies across the Mediterranean basin will be simulated within WP4 in order to identify a set of optimal management practices (i.e. planting density, timing and amount of irrigation and pruning, best suited cultivars, etc.) tailored to maximize olive production and quality as well as olive tree by-products over each climate and management scenarios. A set of environmental sustainability indicators (ESI) and economic viability indicators (EVI) will be identified in WP1 to benchmark the simulation outputs.

The entire project provides for stakeholders engagement through a reiterative approach: relevant stakeholders (farmers, technical advisors, policy and decision makers from each partner countries) will be consulted in order to set up a list of the main olive groves management practices currently applied, with the associated barriers and incentives commonly found in their application, as well as to provide insights into technical and socio-economic aspects affecting the feasibility of management strategies optimized for the future as resulting from WP4.

Fig. 1 - Work plan of OLIVEMIRACLE project

**Expected results and impacts**
Analysis on orchard systems such as olive groves have rarely considered the impact of future climate, due to the lack of adequate tools to estimate the performances of
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these systems under future scenarios. Currently, only a few models for olive tree were so far developed (Moriondo et al., 2015). In this project, the improvement of the OLIVECAN model in conjunction with stakeholders’ interaction will allow to design a complete overview about the best management practices to cope with future climate issues. Project activities have been designed to provide several types of information related to olive tree cultivation. Firstly, it is expected to obtain insights on olive performances under different climate scenarios. Furthermore, the response of olive production under different management options, the risk coming from biotic/abiotic stressors and an assessment of the quality of products and by-products as affected by changes in climate will be among the main outputs of the project.

The research will improve significantly olive tree crop modelling by extending model predictive ability to better capture olive crop behavior under a wider range of conditions. This improved capability will be beneficial to properly support olive farming design and management planning, so that to optimize the performances of the agro-ecosystem in terms of balance between improving positive and reducing externalities. Under this standpoint, an interesting application is the carbon footprint certification, which is attracting a growing interest from stakeholders. As the delivered modelling solution will incorporate a detailed carbon balance algorithm, validated on a wide array of environments, the project has the potential to backbone carbon balance services or refining existing ones. When applied in a global change context, OLIVE-MIRACLE outputs may be considered a valid benchmark for testing the impact of adaptation strategies on both farmers income and ecosystem services, providing stakeholders with knowledge input to refine or re-orient breeding programs as well as the design of field operating machinery. Finally, project outputs have the potential to assess the role of sustainable mitigation and adaptation strategies on the optimization of olive yield and GHGs emissions for olive tree cultivation.

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References

GROWING LENTILS IN A CHANGING ENVIRONMENT: CULTIVAR SELECTION AND PHOSPHORUS FERTILIZATION AS MEANS FOR EARLINESS

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Abstract

Under rainfed conditions, four lentil cultivars [Samos, Thessaly, Flip 2003-24L (Flip), Ikaria] were pre-seeding supplemented with four phosphorus (P) rates [0 (P₀), 30 (P₃₀), 60 (P₆₀) and 90 (P₉₀) kg P₂O₅/ha] during 2013-2014 and 2014-2015 growth seasons. At seven growth stages, two vegetative (V₄-₅, V₇-₈) and five reproductive (R₁, R₂, R₄, R₆ and R₈), growth degree days (GDDs) were calculated. At R₂ stage, biomass carbon isotope discrimination (Δ) was measured to assess water use efficiency. At R₈, an area of 0.125m² was harvested by hand to determine seed yield (SY). Neither cultivar nor P had a significant effect on GDDs of vegetative stages. On the contrary, earliness of the reproductive stages was significantly affected by cultivars, P rates and the P×cultivar and P×year interactions. The high yielding cv. Flip was the earliest (1649.33°C) while the latest maturing (1790.02°C) Ikaria had the
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lowest yield. Phosphorus effects on earliness were cultivar specific. In Flip, high P rates ($P_{60}$ and $P_{90}$) caused significant earliness at R4 and R6 stages. In this line, P induced earliness in cv. Thessaly at R2 and R4 stages. On the other hand, P delayed maturing in Samos and Ikaria at R6. Strong negative correlations between GDDs and SY were found for the $P \times $ cultivar interaction at R1, R2, R4 and R6 stages, with that at R1 to be the strongest ($r= -0.88$, $n= 16$, $P< 0.001$). Alike, negative correlations between GDDs and SY were evident for the $P \times $ year interaction at R2, R4 and R6 stages with that at R4 to be the strongest ($r= -0.98$, $n= 8$, $P< 0.001$). Cultivars showed no significant differences in $\Delta$, which was unrelated to SY or earliness. In conclusion, P addition had cultivar specific effects on earliness of the reproductive stages in lentil.

Key-words: basal temperature, growth degree days, growth stages

Introduction

Climate change is an increasingly worrying challenge, as it has direct biophysical effects on plant physiological processes and consequently on crop production. One of the effects is the decreasing precipitation in the Mediterranean basin causing severe droughts (Benison et al., 2007). While it is difficult to predict accurate scenarios about future climate change, crop productivity remains a key factor affecting food security and economic stability (Hatfield et al., 2011).

Lentil is a grain legume grown around the Mediterranean basin since antiquity and it still remains a structural block of the Mediterranean diet pyramid. Apart from their high nutritional value, legumes and lentils in particular, constitute a food group which can effectively meet the demands imposed by climate change as their environmental impact is minimal (Graham and Vance, 2003). In the Mediterranean region, the crop is usually sown during the wet winter months, but decreasing soil moisture and increasing temperatures during the reproductive stages in spring result in terminal drought and low seed yields (Shrestha et al., 2006). Since lentil meets its needs for nitrogen through $N_2$-fixation, phosphorus is the most common limiting nutrient for growth and grain yield.

Phosphorus (P) is an essential macronutrient with pivotal role in numerous plant processes. It has been reported that P application can promote nodule formation and increase $N_2$-fixation (Reed et al., 2007). The concentration of P in soil is usually low due to its strong fixation to soil particles and P addition is often necessary to achieve high productivity. Also, previous studies have reported the beneficial effect of increased P rates to earliness in flowering and maturity (Saleem et al., 2010).
Therefore, the aim of this work was to study the effect of P fertilization on the earliness and its correlation with seed yield in four lentil cultivars.

Materials and methods

A field experiment was conducted for two growth seasons (2013-2014 and 2014-2015) at the farm of Aristotle University of Thessaloniki (AUTh). Under rainfed conditions, four lentil cultivars [Samos, Thessaly, Flip 2003-24L (Flip), Ikaria], were supplemented, before sowing, with four phosphorus (P) rates [0 (P₀), 30 (P₃₀), 60 (P₆₀) and 90 (P₉₀) kg P₂O₅/ha] in a split-plot design with P rates in the main plots and cultivars in the subplots and with three replications. Phosphorus was applied as triple superphosphate (460 g P₂O₅ kg⁻¹). Each subplot was consisted of six rows, 4-m long and 0.25 m apart (6 m²), with a sowing density of 100-110 seeds m⁻². Breeder’s seeds were used for all the four cultivars.

Observations were made at seven growth stages, two vegetative and five reproductive (Erskine et al., 1990); at the stages of 4-5 th and 7-8 th leaves (V4-5 and V7-8, respectively), while the rest were conducted at first bloom (R1), full bloom (R2), flat pod stage (R4), full pod filling stage (R6) and fully maturity (R8). Each observation was made when at least 50% of the plants in each sub-plot have reached the defined stage.

The calculation of growth degree days (GDDs) was based on the standard single triangle method above the basal temperature (T_base) as follows:

\[ \text{GDDs} = \left( \frac{(T_{\text{max}} + T_{\text{min}})}{2} - T_{\text{base}} \right) \]

The average daily temperature was taken into account whether it was above or below the T_b and a different formula was used for each case according to Feally and Feally (2008). T_base was set to 2°C (Ghanem et al., 2015). The fewer the GDDs, the earlier the cultivar. Daily data for both maximum (T_max) and minimum (T_min) temperature, from sowing to harvest, for both years, were obtained by the nearest meteorological station located in the farm of AUTh.

At full bloom (R2), above-ground biomass was sampled to measure the carbon isotope ratio (δ¹³C) as:

\[ \delta^{13}C (\text{‰}) = \left( \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right) \times 10^3 \]

where \( R_{\text{sample}} \) and \( R_{\text{standard}} \) are the \(^{13}\text{C}/^{12}\text{C}\) ratio in the plant tissue and the standard, respectively. The universally accepted standard of Pee Dee Belemnite (PDB) limestone was used. Carbon isotope ratio was used to calculate carbon isotope discrimination (Δ) as:

\[ \Delta (\text{‰}) = \left( \frac{\delta_y - \delta_x}{\delta_x + \delta_y} \right) \times 1000 \]

where \( \delta_x \) and \( \delta_y \) are the \(^{13}\text{C}/^{12}\text{C}\) ratio in the atmospheric CO₂ and the plant tissue, respectively.
where $\delta_a$ and $\delta_p$ are $\delta^{13}$C of the air and ground leaf sample, respectively. $\delta_a$ is approximately -8‰. At full maturity, a 0.125m$^2$ surface was harvested by hand to determine seed yield (SY).

Data of GDDs for each growth stage were subjected to analysis of variance (ANOVA) as over-year, split-plot design with P rates in the main plots and cultivars in the subplot and with three replications. Means were compared by the least significant difference (LSD) test at $P < 0.05$ and analyses were run using the statistical software JMP 5.1.2 (SAS Institute Inc, Cary, NC, USA).

Results and Discussion

The effects of climate change include high temperatures and prolonged drought periods in the Mediterranean region (Iglesias and Garrote, 2015); so earliness is a desirable trait, especially under the hot and dry conditions prevailing in Greece. Though early sowing could be a means of drought avoidance, its effectiveness is sometimes hindered by negative implications such as increased susceptibility to diseases (Colbach et al., 1997). It has been reported that P fertilization leads to earliness resulting in increased yields (Ayodele and Oso, 2014).

In the present study, neither cultivar nor P had a significant effect on GDDs of the two vegetative stages but on the contrary, earliness of reproductive stages was significantly affected by cultivars, P rates and the P×cultivar and P×year interactions. More specific, at the beginning of flowering (R1), Flip was the earliest and there were no significant differences among P rates, while for Samos, Thessaly and Ikaria the P additions induced earliness compared to controls (Table 1). Similar results were found for full bloom (R2). At R4 stage, P treatments began to stand out in comparison to the unfertilized control. Treatments P$_{60}$ and P$_{90}$ induced earliness in Flip and Ikaria while in cv. Thessaly, all the P additions scored fewer GDDs than control. In cv. Samos, only treatment P$_{90}$ induced earliness (Table 1). At R6 stage, cv. Flip remained the earliest while in cv. Thessaly, all the P rates scored the same GDDs. On the contrary, in Samos and Ikaria, P additions caused delayed maturity (Table 1). Full maturity (R8) was influenced only by cultivar and the cultivar×year interaction, with cv. Flip recording the fewest GDDs (1649.33°C) and Ikaria the highest (1790.02°C). As for the $\Delta$ values there were no significant differences among the cultivars nor P rates. For the cultivars the highest value was found at Flip (22.85‰) and the lowest at Ikaria (22.48‰). As for the P rates, treatment P$_{60}$ scored the highest value (22.75‰) and treatment P$_{90}$ the lowest (22.56‰).

Table 1. Mean comparison of GDDs for cultivar×P interaction for the four reproductive growth stages. Within columns and for the same factor, means labeled with the same letter did not differ significantly at $P < 0.05$ using LSD test.
Over the years, cv. Flip had the highest yield (4063.4 kg/ha) while it was the earliest among the three cultivars; it was followed by Thessaly (3192.5 kg/ha), Samos (2805.5 kg/ha) and finally Ikaria (2698.0 kg/ha), the latest maturing cultivar. However, there was no correlation between P fertilization and SY.

For the P×cultivar interaction, strong negative correlations between GDDs and SY were found at R1 ($r = -0.88, n = 16, P < 0.001$), R2 ($r = -0.82, n = 16, P < 0.001$), R4 ($r = -0.84, n = 16, P < 0.001$) and R6 stages ($r = -0.81, n = 16, P < 0.001$) (Fig. 1). Alike, early maturing affected SY positively for the P×year interaction, where negative correlations between GDDs and SY were evident at R2 ($r = -0.96, n = 8, P < 0.001$), R4 ($r = -0.98, n = 8, P < 0.001$) and R6 stages ($r = -0.96, n = 8, P < 0.001$).

![Figure 1. Negative correlation between GDDs and SY for the P×cultivar interaction at stage R1.](image)

In general, P effects on earliness were cultivar specific, inducing earliness in cvs. Flip and Thessaly and causing delayed maturity in Samos and Ikaria. Rasheed et al. (2010) reported that although P application in lentils induces earliness in flowering, it can delay maturity due to increased nitrogenase activity of active nodules and due to modification of P ratio with other nutrients. The critical stage found to be the

<table>
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<td>1429.17d</td>
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<tr>
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<td>Ikaria</td>
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<td>1104.72c</td>
<td>1265.65c</td>
<td>1450.80b</td>
</tr>
</tbody>
</table>

**yt = -1.368x + 1655**  
$r^2 = 0.88, n=16, P < 0.001$
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beginning of flowering (R1) and earliness seems to be a contributing factor to higher yields.

Concluding, the selection of a proper combination of cultivar and P rate can be a means to increase lentil yields under changing Mediterranean conditions.

References


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EVALUATION OF LAND SUITABILITY FOR OLIVE MILL WASTE DISTRIBUTION ON SOIL

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²Benaki Phytopathological Institute, Department of Phytopathology, Laboratory of Non-Parasitic Diseases

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Abstract

Worldwide, several studies demonstrated that the controlled reuse of agricultural waste onto agricultural land could offer a significant solution for the management of such materials, especially in areas with soils poor in organic matter. For Mediterranean areas and under the threat of progressive soil degradation due to climate change, recycling organic waste on soil seems to be a mitigation practice under the precondition that all appropriate measures for soil protection will be considered and taken.

In the framework of the LIFE Agrostrat project (http://www.agrostrat.gr), a land suitability system, based on FAO land classification method, was developed as decision-making process for pistachio waste recycling on the soils of Aegina Island, Greece. The proposed evaluation system can be adopted by local, regional and national authorities and, most importantly, is flexible to be conformed to different circumstances, legislative restrictions, priorities of authorities and waste types. To ensure soil quality protection, the proposed parameters to be considered for land evaluation were (a) physical and chemical characteristics of the areas of interest, (b) specific soil parameters that are mostly affected by the disposal (i.e. soil indicators), and (c) waste properties.

The aim of this study was to conform the land evaluation system developed for the distribution of pistachio waste on soil to the distribution of olive mill waste (OMW).

Keywords
Climate Changing Agriculture

Land suitability system, olive mill waste, soil, waste disposal, GIS land suitability maps.

Introduction

Climate change that has been intensified over the last few years has caused many problems in the Mediterranean region. One such problem is the threat of soil degradation (low fertility and organic matter) which, due to climate change, creates and urges the need for recycling organic wastes on soils. At the same time, the landspreading of agricultural wastes on agricultural soils seems to be a solution for the management of such materials, mainly when soils are poor in organic matter.

Olive mill waste is a material that requires particular treatment due to its properties, as its misuse can lead to serious environmental problems. Its main characteristics are the seasonal production (from November to February), the intense dark color, the persistent characteristic unpleasant odor, the high water content, the high organic load (COD/BOD5 varies from 2.5 to 5), the low pH (4.5-6), the high content in polyphenols, the high electrical conductivity, the high content of nutrients (mainly in potassium and iron) and the high oil content.

In order to decide agricultural waste landspreading (for disposal or reuse in agriculture), the first step is to ensure compliance with the current legislative framework. Thereafter, the suitability of the area of interest to accept waste should be evaluated. Soil suitability depends on: a) geomorphological characteristics of the area and b) waste type. Regarding waste type, as it was revealed, different types of waste affect different soil parameters (LIFE Prosodol, 2012; Doula et al., 2013; LIFE Agrostrat, 2016). For pistachio waste, it was found that the soil parameters that are mostly affected are electrical conductivity, organic matter, total nitrogen, available phosphorus, total polyphenols, exchangeable potassium and available copper and zinc (LIFE Agrostrat, 2016), while for OMW pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, total polyphenols, exchangeable potassium and available iron (LIFE Prosodol, 2012).

In this paper, a land evaluation system was developed for the distribution of OMW, using Aegina island as pilot area aiming at ensuring the qualitative characteristics of soil and groundwater receiving OMW.

Methodology

Aegina Island is divided in 140 soil mapping units, according to the soil map, which was produced during LIFE Agrostrat project (2016). The land evaluation system for the distribution of OMW developed by the system for pistachio waste (LIFE Agrostrat, 2016) conformed to the specific characteristics of OMW. Two maps may be produced, one for landspreading of solid OMW and one for olive mill wastewater (OMWW). Therefore, two groups of soil parameters were considered, i.e. general physicochemical parameters that must be considered for evaluating an area for waste disposal and are common as in case of pistachio waste; and the soil indicators identified by Doula et al. (2013) specific for OMW landspreading (Tables 1 and 2). Table 1 illustrates the categorization of the soil parameters for OMWW landspreading, while Table 2 the respective classification for solid OMW. Tables 3 and 4 include explanation on soil parameters and their thresholds. The respective thresholds for the soil indicators have been defined by Doula et al. (2013).

Table 1. Parameters taken into account for soil evaluation for OMWW landspreading.

<table>
<thead>
<tr>
<th>Soil parameters</th>
<th>FAO Suitability Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>Depth of aquifer, m</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Slope</td>
<td>A</td>
</tr>
<tr>
<td>Drainage</td>
<td>A</td>
</tr>
<tr>
<td>Erosion</td>
<td>0</td>
</tr>
<tr>
<td>Soil depth</td>
<td>6, 5</td>
</tr>
<tr>
<td>On-site wastewater management</td>
<td>A</td>
</tr>
<tr>
<td>Salinity, dS/m</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Infiltration</td>
<td>0.5-16</td>
</tr>
<tr>
<td>ESP, %</td>
<td>0-6</td>
</tr>
<tr>
<td>pH</td>
<td>7.3-8.4</td>
</tr>
</tbody>
</table>
### Table 2. Parameters taken into account for soil evaluation for solid OMW landspreaing.

<table>
<thead>
<tr>
<th>Soil parameters</th>
<th>FAO Suitability Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>Depth of aquifer, m</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Slope</td>
<td>A, B</td>
</tr>
<tr>
<td>Drainage</td>
<td>A, B</td>
</tr>
<tr>
<td>Erosion</td>
<td>0, 1</td>
</tr>
<tr>
<td>Soil depth</td>
<td>6, 5, 4</td>
</tr>
<tr>
<td>Salinity, dS/m</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Infiltration</td>
<td>0.5-16</td>
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<tr>
<td>ESP, %</td>
<td>0-6</td>
</tr>
<tr>
<td>pH</td>
<td>7.3-8.4</td>
</tr>
<tr>
<td>EC, mmhos/cm</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Total Nitrogen, %</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Phosphorus, mg/kg</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Potassium, cmol/kg</td>
<td>&lt;0.26</td>
</tr>
<tr>
<td>DTPA-Fe, mg/kg</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Polyphenols, mg/kg</td>
<td>&lt;50</td>
</tr>
</tbody>
</table>

### Table 3. Soil parameters and their symbols.

<table>
<thead>
<tr>
<th>Soil Parameters</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>A: 0-3%</td>
</tr>
<tr>
<td></td>
<td>A: Very well drained</td>
</tr>
<tr>
<td>Drainage</td>
<td>A: Good</td>
</tr>
<tr>
<td></td>
<td>A: 10-15% very shallow</td>
</tr>
<tr>
<td>Soil depth, cm</td>
<td>A: 10-15% very shallow</td>
</tr>
<tr>
<td>Erosion</td>
<td>A: No erosion</td>
</tr>
</tbody>
</table>

### Table 4. On-site wastewater management parameter (CCME, 2007).

<table>
<thead>
<tr>
<th>On-site wastewater management</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well drained soils, with &gt;35% clay, soil depth &gt;1.0 m, gravel &lt;10%, slope &lt;5%.</td>
<td>A</td>
</tr>
<tr>
<td>Moderately well drained soils, with &gt;20% clay, moderately deep (0.5-1.0 m), gravel 25-50%, slope 5-10%.</td>
<td>B</td>
</tr>
<tr>
<td>Not completely drained soils, with &gt;15% clay, moderately shallow (0.25-0.5 m), gravel &gt;50%, slope &gt;10%.</td>
<td>C</td>
</tr>
<tr>
<td>From badly up to very badly drained soils or flooded soils. The disposal of olive mill wastes is not recommended during floods.</td>
<td>D</td>
</tr>
</tbody>
</table>

The suitability of each area was evaluated on the basis of the Land Evaluation System of FAO (1976), which categorizes land into five suitability classes (Table 5). Each soil mapping unit of Aegina Island was evaluated, considering soil parameters and the respective GIS maps were developed, using ArcMap 10.4 (ESRI Inc.).
Table 5. Land Suitability Classes according to FAO (1976).

<table>
<thead>
<tr>
<th>Suitability Classes</th>
<th>Description</th>
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<tbody>
<tr>
<td>S1 Highly Suitable</td>
<td>Land having no significant limitations to sustained application for waste disposal or reuse or only minor limitations. Nil to minor negative economic, environmental, health and/or social outcomes.</td>
</tr>
<tr>
<td>S2 Moderately Suitable</td>
<td>Land having limitations which in aggregate are moderately severe for sustained application of waste. Appreciably inferior to S1 land. Potential negative economic, environmental, health and/or social outcomes if not adequately managed.</td>
</tr>
<tr>
<td>S3 Marginally suitable</td>
<td>Land having limitations which in aggregate are severe for sustained application of waste. Moderate to high risk of negative economic, environmental, health and/or social outcomes if not adequately managed.</td>
</tr>
<tr>
<td>N1 Not Suitable</td>
<td>Land having limitations, which may be insurmountable. Limitations are so severe as to preclude successful sustained waste disposal or reuse. Very high risk of negative economic, environmental and/or social outcomes if not managed.</td>
</tr>
<tr>
<td>N2 Not Suitable</td>
<td>Land having limitations which appear so severe as to preclude any possibilities of successful sustained waste disposal or reuse in the given manner. Almost certain risk of significant negative economic, environmental and/or social outcomes</td>
</tr>
</tbody>
</table>

Results and Discussion

Maps 1(a) and 1(b) present the suitability of Aegina island for the disposal or reuse of OMWW (Map 1a) and solid OMW (Map 1b). The suitability class of each mapping unit resulted from the parameter with the highest limitation considering Tables 1 and 2. The main limiting factors for the disposal of OMWW are slope, soil depth and on-site wastewater management parameter, while for solid OMW are slope, soil depth and the electrical conductivity.
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Map 1. Land Suitability Maps for the disposal of (a) olive mill wastewater, (b) solid olive mill waste for the Island of Aegina, Greece.

Suitability maps are a powerful decision-making tool that can assist authorities in deciding the most appropriate areas for waste landspreading, based on the evaluation of soil properties and mainly of the specific properties that are anticipated to be affected by landspreading, i.e. the soil indicators. The consideration of soil indicators makes the system unique for each waste type. Such indicators have been already identified in case of OMW and pistachio waste instead of other waste types. Since the proposed land evaluation system can be used for all waste types by using the soil indicators for each specific waste type, the definition of soil indicators is highly recommended. However, this requires performing a methodological study accompanied with scientific- and field- work, meaning that human and financial resources should be available. If such a methodological study cannot be performed, then some common and sensitive soil parameters can be evaluated instead, which are soil pH, electrical conductivity, polyphenols, total organic carbon, nitrogen, phosphorus, zinc and copper (Doula et al., 2016).

Conclusions

Land suitability maps provide spatial and quantified data on soil quality and suitability to receive waste. Therefore, they are powerful decision-making tools for assisting authorities in developing local actions plans and in deciding the sites of disposal and also in estimating the appropriate amount to be applied on soils, based on the available quantitative soil data and the respective quality thresholds.

References


ESRI. https://www.esri.com/en-us/home


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EFFECT OF SOIL ACIDITY ON SELENIUM ACCUMULATION IN LETTUCE (Lactuca sativa L.) AND BERSEEML (Trifolium alexandrinum L.) PLANTS, AS AFFECTED BY THE APPLICATION OF SODIUM SELENATE

M. Tsioubri\textsuperscript{1}, D. Gasparatos\textsuperscript{2} and M. Oikonomou-Eliopoulos\textsuperscript{3}

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\textsuperscript{2} Faculty of Agriculture, Aristotle University of Thessaloniki, 54124, Thessaloniki
\textsuperscript{3} Faculty of Geology and Geoenvironment, National and Kapodistrian University of Athens, Zografou, 15784, Athens

Abstract

The effects of selenium (Se) addition as sodium selenate (Na\textsubscript{2}SeO\textsubscript{4}) M on production of lettuce (Lactuca Sativa L.) and berseem (Trifolium alexandrinum L.) were investigated. The experiment was conducted under greenhouse conditions with two different soil types, an acid (pH = 5.6) and an alkaline (pH = 7.8) soil in a completely randomized factorial design. The results indicate higher selenium content in berseem cultivated on acid soil. The decreased selenium content in plants cultivated on the alkaline soil are probably due to the presence of high organic matter content (4-8\%). It was also observed significant reduction (~ 45\%) in plant biomass of lettuce in the acid soil combined with selenium application.

Keywords: selenium, bioaccumulation, Trifolium alexandrinum, Lactuca sativa, pH, organic matter, sodium selenate

Introduction

Selenium (Se) belongs to Group VI\textsuperscript{A} of the Periodic Table with an atomic weight 78,96 (\approx 79), and has similar chemical properties to oxygen, sulfur, tellurium and polonium being elements of the same group of Periodic Table (Broadley et. al. 2006). The range of concentration values in cortex and mantle ranges from 0.03 to 4.08 mg /kg and 0.09 mg /kg, respectively. In the global classification of soil selenium, countries with high concentration values of Se is China, N. Zealand, Canada, the United States of America (USA), Australia and India. In soils, Se may be present naturally as a result of weathering processes and/or anthropogenic activities such as mining and refining processes of sulfide ores. In the natural environment, selenium occurs in four oxidation states with valences 6\textsuperscript{+}, 4\textsuperscript{+}, 2\textsuperscript{−} and 0 (elemental form). The main source of Se is the geological bedrock, however there are soil parameters which determine its bioavailability into the plants and through them into the food chain. The
mobility and absorption of Se is controlled by the redox potential (Eh), the percentage of organic matter, soil classification, the clay percentage, the oxidation state of the element (chemical form), the soil acidity (pH) and the presence of competitive ions (Funwie, 2012). The plant species constitute a link between soil and animal species on the uptake and transfer of Se to the higher nutritional levels. Plants according to their ability to accumulate selenium in their tissues are divided into three major categories: i) the hyperaccumulators plants, with concentration levels ranging from 1000 to 10000 mg / kg dw, ii) the secondary accumulators or indicators, which rarely exceed a few hundred to a few thousand ppm Se concentration in their tissues and iii) types of grass, trees and some weeds, which generally accumulate less than 100 ppm / kg dry matter (Hasanuzzaman et al., 2010, Ralston et al.2008, Dhillon 2003). The effects of Se on human health were identified for the first time in 1957, almost a century after its discovery. It has been identified as a necessary component of glutathione peroxidase enzyme (GPx) and its adequacy may prevent hepatic necrosis due to lack of vitamin E, preventing cardiovascular disease, muscle disorders, cancers, diabetes Type 2 appearance, and also plays an important role in male fertility. (Johnson C.C. et al., 2010, Patikas D., 2012, Kumar and Priyadarsini 2014, Cobo-Angel et al., 2014, Moghadaszadeh and Beggs, 2006). The aim of this study was to evaluate the effect of selenate addition on the yield and Se uptake of two different cultivars (lettuce and berseem) grown on two different soil types (acid and alkaline soil) under greenhouse conditions.

Materials and methods

The experimental procedure was carried out in a greenhouse of the Agricultural University of Athens, under controlled external environment conditions. The plant representatives chosen were, the genus Lettuce sativa sp. and Trifolium alexandrinum, as consumption’s indicators of human and domestic animals, respectively. The soils were categorized into alkaline and acidic and were placed and in pots of 2 kg, each of them. The chemical form of Se was the sodium selenate (Na$_2$SeO$_4$ 1 M, ) and the application of the chemical reagent at dose of 5 mg l$^{-1}$ was done into two stages, with an interval of two months. Finally, the irrigation dose, which applied to all samples throughout the cultivating process, was 75 ml / sample. The soil parameters, which were measured for soil samples, were the organic matter, the soil acidity (pH), the particle size distribution, the available phosphorus, the content of calcium carbonate (CaCO$_3$), as well as the exchangeable soil cations Ca, Mg, and K. The bioavailable soil selenium was determined by the AB-DTPA extraction method and was measured by hydride generation atomic absorption spectroscopy (HGAAS). In order to be measured Se in plants, the plant tissues were separated into shoots and roots, followed washing with deionized water and placing in a laboratory oven for 3 days at approximately 40 °C. Due to the high evaporating ability of selenium, the autoclave combustion of high pressure was used. The sample (0.5 g) was placed in cylindrical porcelain capsule, with 1 ml of hydrogen peroxide (H$_2$O$_2$) and 6 ml of concentrated nitric acid (HNO$_3$). The solutions were transferred to volumetric flasks (50 ml) and the Se was determined by the ICP-MS method. Data processing, derived from bioavailable selenium and plant biomass measurements, was performed by ANOVA method in StatGraphics program. Significance of differences was evaluated at the 5% level.
Results and discussion

According to the results of the study, the existence of high amount of organic matter and phosphorus of the soil samples varied depending on the soil type and cultivation. The acidic soil showed reduced organic matter, compared with the alkaline soil with the addition of a significant amount of compost. According to the measurements of the plant tissues of the lettuce, was observed an important difference of Se concentration in pH 6.6 – 8.0. Based on the results, a higher concentration of Se in whole plant samples observed at slightly acidic to neutral soil acidity ranges. Similar chemical behavior showed the concentration of Se in the root samples. Contrary to the lettuce crop, berseem samples showed strong accumulation of Se concentrations in the acid soil. For neutral and slightly alkaline pH values, the absorption of Se was reduced drastically. Between the two cuttings, which were carried out during the growing season, a strong differentiation of the concentration values occurred in the acidic range of pH, with emphasis on the first cutting. The Se content of the plant tissues independently of the crop, was higher in acidic soil in relation to the alkaline, whereas the control-samples were not affected by the soil type, in contrary to the samples (Fig.1A). The selenium content of plant tissues, independently of the soil type, appeared to accumulate similar amounts of the element, in two types of treatment (controls and repetitions). However, after chemical reagent adding, the Se accumulation in plant tissues was higher in berseem than lettuce (Fig.1B), due to the ability of Fabaceae to absorb high levels of Se (Zhang Mu et al, 2014).

![Interaction between type of soil and treatments](image_url)
As shown in Figure 2A, a negative relationship of soil pH with the fresh weight of lettuce, suggesting that under acidic conditions the growth of lettuce was significantly restricted. Conversely, about berseem crop the effect of soil type was less important. The existence of a significant reduction of the above-ground biomass of lettuce after Se treatment, is shown in Figure 2B, reduction of almost 45% compared to berseem crop (Ramos et al., 2010). The presence of a significant amount of organic matter in the alkaline soil increases the Se adsorption from the organic colloids, making it water-insoluble, ultimately resulting decreasing absorption by plants (Li Zhe et al., 2017). However, among the two cultivars was observed higher concentration of Se in Trifolium alexandrinum shoots. Maintaining the pH at constant values, the only factor affecting the Se absorption from the roots is the organic matter content, as is the case of Trifolium alexandrinum.
It was, also, observed no effect of the crop type factor for the control plants since they absorbed the same amount of Se, contrary to the treatments plants in which the highest concentration of the Se occurred in *Trifolium alexandrinum*. About the plant tissues, controls showed the same amount of Se in shoots and roots, while double content of the Se was measured in leaves, independently cultivation. The above observations lead to the conclusion that significant changes in the Se absorption from plant tissues, occurs in soils enriched with Se. Finally, depending upon the soil acidity and type of plant tissues, it was observed that in acidic conditions, Se translocation from roots to above-ground plant part was intense, in contrast to the alkaline environment, in which Se transport was characterized as limited. Given of the multitude of research studies based on geochemistry and chemical behavior of selenium in the soil, in combination with cultivated plant species, we conclude that high levels of organic matter are able to restrict the role of soil acidity of Se absorption by plants.

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ASSESSING BIODIVERSITY AND ITS ECOSYSTEM SERVICES IN ANDALUSIAN OLIVE ORCHARDS THROUGH THE LANDSCAPE MODERATION HYPOTHESIS APPROACH

Pedro J. Rey1, Francisco Valera2, Antonio J. Manzaneda1, Julio M. Alcántara1, José L. Molina-Pardo1, Rubén Tarifa1, Jorge Isla1, Teresa Salido1, Gemma Calvo1, Carlos Martínez-Nuñez1, Carlos Ruiz2 y José E. Gutiérrez1.
2 Estación Experimental de Zonas Áridas, EEZA-CSIC, Ctra de Sacramento s/n, La Cañada de San Urbano, 04120, Almería

Abstract
Among the arboreal croplands, the olive tree plantations are the ones with the strongest economic impact in Europe as well as with higher importance for biodiversity maintenance in the Mediterranean Basin. Compared to annual crops, the stability of arboreal croplands makes olive plantations especially favourable for biodiversity establishment and recovery. To this sums that, the cultivated species was developed from a common wild tree from the same region where it is mainly cultivated, thus keeping many ecological and evolutionary relationships with the wild vertebrate and invertebrate fauna. There is evidence that agricultural practices have pauperized considerably plant and animal biodiversity in olive croplands. Nevertheless, the knowledge of the biodiversity supported by olive plantations is rather limited and even more incipient is our understanding of the consequences of biodiversity loss for ecosystem services in this culture. As part of a long-term project
on biodiversity and ecosystem services recovery in olive plantations, we present here the first regional evaluation of biodiversity of olive orchards in Andalusia (Southern Spain) and of the factors affecting it. Our study is framed in recent conceptual advances on the modulating effects of landscape on biodiversity and ecosystem services enhancement through extensification practices, i.e., ‘the hypothesis of the landscape moderation of biodiversity pattern and function’. We report here preliminary results on plant and animal biodiversity in relation to landscape complexity, extensification-intensification practices (density of plantation and herbaceous cover management), property size (related to the scale of management) and climatic-geographic features. We further present preliminary data on some pollinator services by insects. Our results are based on 20 pairs of farmlands (each pair composed by intensified and extensified olive farmlands) distributed throughout Andalusia, encompassing 300 km of olive orchard landscapes and substantial differences in mean rainfall and temperature. We used birds, ants and insect pollinators as indicators of animal biodiversity, and herbaceous cover as indicator of plant biodiversity. We aim to provide (1) a complete picture of how biodiversity is being affected by intensification of agricultural practices in olive plantation landscapes and (2) a diagnostic of the opportunity for enhancing biodiversity and ecosystem services by extensification, after considering the landscape complexity scenery of each olive farmland.

Keywords
Olive trees, biodiversity, landscape complexity, birds, ants, weeds, pollinators, Sinapis alba, agriculture extensification.

Introduction

The preservation of biodiversity in farming landscapes is being promoted under the premise that biodiversity provides fundamental ecosystem services to farming (Scherr and McNeely 2008, Swift et al. 2008, Tscharntke et al. 2012). This is even more important under the increased demand of food (and hence land for farming) in next decades. The relevance of integrating sustainable crop production and biodiversity conservation is presently encouraging agricultural policies, such as the Agri-Environmental Schemes (AES) of the European Common Agricultural Policies (CAP), and novel lines of research, including ecological restoration (Swift et al. 2004; Rey-Benayas & Bullock 2012). However, to enforce these policies and the restoration efforts we need to consider how biodiversity levels in farmlands relate to intensification-extensification agricultural practices and to the complexity of the agricultural landscapes (Tscharntke et al. 2005, 2012; Concepción et al. 2012) since the remnants of natural habitats are the ultimate sources for biodiversity in human-modified landscapes. This information is however still scarce for most crops worldwide and particularly for arboreal croplands. As a part of a long-term study on the evaluation and restoration of biodiversity and its ecosystem services in olive croplands of Andalusia, here we provide an initial report of fauna (birds and ants) and flora (weeds) biodiversity in relation to intensification practices and landscape complexity in 20 olive orchards landscapes distributed over the areas of highest olive production in Spain. Olive plantations are the arboreal cropland with highest economical relevance in Europe, and one of the most relevant crops for maintenance
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of birds and other vertebrate biodiversity (Rey 1993, 2011, Castro-Caro et al. 2014, 
2015, Carpio et al. 2015, 2016) but its biodiversity, the ecological services it provides 
and how they are affected by the agricultural practices and the landscape complexity 
remain understudied. With this information we tested major proposals of the 
landscape moderation hypothesis of biodiversity patterns and processes, LMHB, 

Methods
For one year, we conducted monthly surveys of birds, weeds, and epigeal ants in 20 
pairs of olive farms distributed across more than 300 km within the highest olive 
production area. Our monitoring program involved six 50m-radius circular sampling 
stations in small olive properties and 10-12 sampling stations (depending on the group 
of organisms) in large olive properties, with 40% of these stations being located in 
non-cultivated sites and 60% in productive sites of each property. All these stations 
were geo-localized with GPS and uploaded in a GIS platform from which we assessed 
landscape and patch scale metrics. Olive landscapes and farmlands were chosen based 
on: i) property size, ii) degree of agricultural intensification (weed management 
techniques, i.e., eradication of the herbaceous cover during the year versus persistent 
herbaceous cover), iii) complexity of the surrounding landscape. From our surveys we 
derived an estimation of species richness for each group of organisms using species 
accumulation curve techniques (Gotelli y Colwell 2001) and subsequently averaged 
the species richness estimation across groups for each farmland. We then estimated 
the relative increase in species richness by changing from an intensive to an extensive 
management of the herbaceous cover within a given landscape. This was calculated as 
the difference between the species richness in farmlands with and without herbaceous 
cover of each locality divided by the species richness of the farmland with herbaceous 
cover.

We further examined the variation in pollinator service by changing from 
intensive to extensive management for a non-crop, multi-functional annual herb 
(yellow mustard, Sinapis alba, Brassicaceae) that contributes to soil retention, 
increased water infiltration, control of some fungi diseases of the olive tree and 
mustard production). Pollinator service was measured in terms of pollinator diversity, 
flower visitation rate and seed set in several patches of the species in the study olive 
farms.

Results and discussion
We detected more than 500 different weeds species, 60 ant species and 165 bird 
species in our surveys in olive groves, what reinforces the idea that olive landscapes 
still retain a notable biodiversity. The biodiversity harbourd by the olive farms 
(considered as the across-taxonomic groups mean estimated species richness) 
depended both on the management of the herbaceous cover ($F_{2,14} = 5.65, P = 0.016$) 
and on the landscape complexity ($F_{1,14} = 10.47, P = 0.006$). As expected from the 
LMHB, mean species richness increased with the maintenance of weed cover and 
with the landscape complexity. The increase in species richness peaked when the 
extensification of the agricultural practices occurred at intermediate levels of 
landscape complexity (Fig 1 a), while increases in species richness were rather low or 
inexistent at very low or high levels of landscape complexity (Tscharntke et al. 2005). 
Likewise, the increase in pollinator service for yellow mustard with the 
extensification of the herbaceous cover management peaked at intermediate levels of
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landscape complexity (Fig 1b) as shown by pollinator visitor diversity and flower visitation rate.

Fig. 1. a) Effectiveness in recovery of species richness by extensification of the management of the herbaceous cover. b) Pollinator service for yellow mustard (pollinator visitation rate) in olive groves with and without herbaceous cover and its variation according to landscape complexity. Similar pattern is found for pollinator visitor diversity, while fruit set substantially decreases in absence of weeds with the landscape complexity which means that recovery of fruit set by extensification increases with landscape complexity ($F_{2, 132} = 3.78, P = 0.025$)

Our results thus corroborate some of the major predictions of the LMHB concerning biodiversity patterns and effectiveness of agri-environmental practices to recover biodiversity and ecosystem services in the olive landscapes. Several management recommendations can be extracted from our results: (1) It is necessary to strengthen agro-environmental policies promoting the shift from intensive to extensive management of the herbaceous cover in olive groves (weed maintenance all the year round and mechanic mowing in late spring), as well as a more strict implementations of the greening policy of the EC in this culture; (2) In order to an effective recovery of biodiversity and ecosystem services in olive groves by changing from intensive to extensive management of weeds, specific actions directed to diversify the olive landscapes through restoration of natural elements in unproductive zones (green infrastructures) should be implemented, especially in simple olive-dominated landscapes. Such restoration practices are being now implemented in our study locations via a demonstrative LIFE project (OLIVARES VIVOS) that assumes the results and recommendations here presented.

Acknowledgements

This work was funded by LIFE project ‘Olivares Vivos’ (LIFE14 NAT/ES/001094) of European Commission and the project AGRABIES (CGL2015-68963-C2-1-R) of Ministerio de Economía y Competitividad. We are grateful to the owners of the olive farmlands of this study by allowing us to conduct our surveys of biodiversity.

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OLIVARES VIVOS (OLIVES FOR LIFE): TOWARDS THE DESIGN AND CERTIFICATION OF BIODIVERSITY FRIENDLY OLIVE GROVES.

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Abstract

Olive tree cultivation is one of the most representative crops of the Mediterranean region and a key crop to halting the loss of biodiversity in Europe. Due to intensification of the farming management, its biodiversity is getting lost and its ecosystem services are being deteriorated. When dealing with crops, the solution must be related with the profitability. The LIFE project Olives for Life proposes to use the potential of biodiversity conservation as an added value for the olive oil, available for the consumers willing to contribute to biodiversity conservation through a certification label. It is based on a) demonstrative actions implemented in 20 different olive groves where habitat restoration work will be carried out and its results fully monitored, b) production, commercialization and marketing actions to bring the certification label in the market and c) actions to promote externalities of the olive cultivation, to communicate about the project and to build a strategy so the results will be useful to influence in the Agricultural and environmental European policies. The project is expected to open an innovative way of biodiversity management in agro-ecosystems, following a bottom-up model of participation for local communities and involving key stakeholders, farmers and consumers in the solution of the problem.

Keywords

Olive trees, biodiversity, certification, added value, consumers, Olives for Life,
Introduction

Olive tree cultivation is one of the most representative crops of the Mediterranean region. Its distribution shares almost the same limits as the Mediterranean hotspot for biodiversity (Mittermeier 2005). The areas with the highest conservation value within this region either include olive trees or are surrounded by olive groves. Preserving biodiversity hotspots is a priority for nature conservation. Olive groves are a key crop to halt the loss of biodiversity in Europe, and due to its distribution, its semi-forest characteristic and because it is a native plant from the Mediterranean, it has a great potential to recover this biodiversity. (Herrera 1983, Rey, 1993, 2011).

In the last decades, successive steps of expansion and intensification of the crop have resulted in an important loss of its biodiversity, producing serious environmental damages (Allen et al 2006, Muñoz Cobo et al 2001, Sokos et al 2013). This effect has been especially severe in the traditional olive groves (Rey 2011, Paredes et al. 2013, Castro-Caro et al. 2015) and especially noticeable on birds (SEO/BirdLife, 2015, Gutiérrez 2002, Gutiérrez et al. 2013). Most of these damages are related with the removal of natural vegetation from the unproductive areas of the cultivation fields. These damages have triggered a deterioration of the ecosystem services previously provided by the olive groves (Tilman et al 2002, De la Concha et al 2007, Gómez-Calero et al 2009). As a consequence, the landscape of the olive areas has been greatly simplified (Guzmán, J.R. 2004, Sánchez, J.D et al. 2008).

When dealing with crops, the solution must be related with the maintenance or improvement of profitability. On the other hand, each year the concern about biodiversity conservation of European citizens and institutions is increasing. (European Commission 2013). We aim to use the potential of nature conservation as an added value for the final product (olive oil), thus connecting farmers and consumers with a common objective: preserving biodiversity.

Under these conditions we started the European Union funded LIFE Project Olivares Vivos (Olives For Life), with a strategic approach that transcends the agro-environment to be located in the agri-food sector. The main objectives of this project are: 1) to design an olive growing management model, scientifically supported, that preserves and recovers biodiversity, 2) to place, through a certification label (Olivares Vivos), this added value in the final product (olive oil) and 3) to develop the best strategy to turn this added value in profitability for the producers.

Material and Methods

The project is structured into three main interconnected lines of action.

1. Habitat restoration and monitoring action line. It includes: a) Selection of 20 demonstrative olive groves, following scientific criteria to include the main variables that describe the variety of olive groves that can be found in Andalusia. b) a one year-long survey of the pre-operational condition of the demonstrative olive groves, monitoring different biodiversity indicators (herbaceous and woody vegetation, epigeal insects, birds, pollinators and specific pest insects, seed dispersal ecosystem service), c) design and implementation of action plans to recover biodiversity in the demonstrative olive groves, d) a one year-long survey of the post operational conditions (monitoring the same indicators as in the pre operational survey) and e) set up of the certification criteria and procedure.

2. Market action line. It includes actions to: a) Create a certification label, b)
perform market surveys and c) design a production and commercialization strategy. There will be also actions to d) assist olive growers in the production and commercialization process through informative meetings, networking initiatives and strategic agreements with olive mills, distributors and points of sale.

3. Communication and promotion action line. It includes actions to a) analyse and promote the cultural externalities of the olive cultivation, by means of searching of sources of knowledge about olive culture, schoolchildren campaigns, innovative oleo tourism tests, b) communicate about the project, its results and about the certification label and its meaning, c) create a municipalities network to support the project implementation and to help with its replication after the end of the project and d) to build a strategy to communicate the results and to make recommendations based on the results the European Commission to be taken into account in further revisions of the Common Agriculture Policy.

Results and discussion
The results obtained so far confirm some of the premises needed to assure the feasibility of the proposed strategic approach: a) the pre operational survey of biodiversity shows that there is a potential to recover biodiversity in the olive groves. (Rey et al 2017). b) 20 demonstrative olive farmers have signed land stewardship agreements with the project, totalling more than 3600 ha, thus showing that there is a true commitment of an important part of the olive sector to implement strategies that focus in the environmental added value of their olive oil and c) a survey conducted under the frame of this project among 640 olive farmers in 88 municipalities of Andalusia shows that 69% of the farmers considered that there is an environmental crisis in the olive sector, showing that society and particularly olive sector is concerned about their environmental problems. In the same survey, 87% of farmers were willing to improve the environmental conditions of their groves if this could be linked with higher profitability.

The innovative approach to work on biodiversity conservation in agro-ecosystems proposed by the project brings several benefits: 1) It offers different attracting factors to each of the stakeholders involved; a biodiversity conservation strategy for conservation and scientific organizations, a new way of differentiation and profitability for the farmers, an innovative product for the olive oil market and a consumption option for the consumers, opening them to the possibility of being proactive and to make their own contribution to biodiversity conservation. 2) The involvement of the olive growers in the project helps to spread good environmental management practices among the farming sector and c) ease to establish synergies and alliances between farmers and conservationists in order to face together the environmental challenges of agriculture. d) This joint work of conservationists and farmers provides strength to influence in the agricultural and environmental policies.

Moreover, the approach of the project is based on a bottom-up conservation model. It relies on the initiative of the farmers and the decisions of the consumers as basic premises for its consolidation. Bottom-up conservation models have shown to be more effective than the more common top down models (Betancourt Posada 2008, BirdLife International 2010). Effective participation and empowering of local communities in conservation projects are some of the specific objectives in conservation strategies of governments and NGOs (Convention on Biological Diversity, 2010).

The approach proposed in Olivares Vivos opens a promising new way of managing
biodiversity in agro ecosystems.

Acknowledgements
The project is possible thanks to the farmers involved in the demonstrative actions. And of course thanks to UE LIFE programme, “Patrimonio Comunal Olivarero” Foundation, “Interprofesional del Aceite de Oliva Español”, GEOLIT, Guillermo García SL and Spanish Federation of Forest Plant Nurseries.

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WATER STATUS AND BIOMASS RESPONSE OF TWO OLIVE TREE CULTIVARS UNDER WATER STRESS

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Abstract:
Water resources in semi-arid and arid zones of the Mediterranean basin are under increasing pressure from rapidly growing demands and climate change conditions. Under present climate variability, water stress is already high and climate change adds even more urgency for action. The effect of two water stress levels compared to the control water treatments (100%, 50% and 0% Available Water Content (AWC)) was investigated on olive one-year-old plants in order to assess the behavior of olive trees in water stress conditions. Chemlali T50% plants had the best response under water stress conditions by decreasing their osmotic potential to maintain regular water potential and develop the best root/shoot ratio. This response indicates that olive tree management strategy to mitigate water stress depends on the specific adaptive cultivar mechanisms.

Keywords: *Olea europaea* L., Leaf water status, Plant dry matter accumulation, Osmotic adjustment, Root/shoot ratio.

Introduction:
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The olive tree is tolerant to drought because of its specific morphological mechanisms (extensive root system, stomata located on the underside of leaves, etc.) (Gimenez et al., 1997). The olive tree is well adapted to tolerate drought and can survive and produce fruit with little water available (Girón et al., 2015, Torres-Ruiz et al., 2015), a trait which is associated with the ability of the species to maintain photosynthesis and perspiration at low water potential (Sofo et al., 2007). Despite being one of the most resistant species, the physiology of the olive tree is also affected by the lack of soil water. In this context, the main aim of this work was to assess the behavior of two young olive tree cultivars Koroneiki, which is a promising Greek cultivar for oil production, and Chemlali, the best local cultivar for oil production, under three water treatments. The comparison between the two cultivars was based on leaf water status and dry matter accumulation parameters. This study is essential to select the most suitable cultivar for Mediterranean environments subjected to water shortage conditions.

Materials and Methods

- Plant material and water treatments
  One-year-old olive trees (Koroneiki and Chemlali) were grown in 4L plastic pots in a greenhouse at the Tunisian Olive tree Institute (Tunisia, 35 49’N, 10 38’E) under normal day-light conditions. The experiment was conducted from March, 16th to April, 21st 2015. Three water treatments were applied:
  - T100%: Control treatment: Daily irrigation at 100% of Available Water Content (AWC),
  - T50%: Daily irrigation at 50% of AWC,
  - T0%: Without watering.

- Leaf water status measurements
  Plant water status was determined by measuring the total leaf water potential ($\Psi_w$) on fully expanded leaves with a thermocouple psychrometer (sample chambers type C52; Wescor, Logan, Utah, USA). Active osmotic adjustment (AOA) was defined as the difference between $\Psi_{\pi}$ at full turgor measured at predawn for the 100% AWC treatment ($\Psi_{\pi100}$) and the two other treatments T50% and T0% ($\Psi_{\pi100}(T50\%$ and T0%)) plants. The contribution of passive osmotic adjustment (POA) to OA via the loss of symplastic water was determined as: $POA = OA – AOA$
  The osmotic adjustment and its compounds were taken in the end of the experiment (April, 21st 2015), in three replicates for each treatment and cultivar.

- Plant dry matter accumulation parameters
  At the end of the water stress application (April, 21st 2015), plants destruction was done in order to determine the root/shoot ratio.

Results and Discussion

- Effect of three water treatments on leaf water status
- Effect of three water treatments on leaf water potential ($\Psi_w$)
  No significant difference was noticed between T100% and T50% for the two cultivar plants during the experiment period (Table 1). It should be noted that a significant difference between Koroneiki and Chemlali plants was recorded in T0%. According to these results, we can deduce that Chemlali plants are more tolerant to water restriction than Koroneiki plants. For both
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cultivars, Irrigation at 50% AWC permits to maintain regular leaf water potential. Our results are similar with those obtained by Girón et al. (2015) and Marino et al. (2014).

Table 1. Effect of three water treatments on the leaf water potential ($\Psi_w$; MPa) of olive tree (*Olea europaea* L. cv Koroneiki and Chemlali). Each value represents the mean ± standard deviation of three measures. The average of each value followed by the same letter do not differ statistically between treatment - SNK P <5%.

<table>
<thead>
<tr>
<th>Days after applying water treatments</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Koroneiki</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T100%</td>
<td>-3.09±0.30a</td>
<td>-3.48±0.52a</td>
<td>-3.38±0.21a</td>
<td>-3.34±0.12a</td>
<td>-3.63±0.35a</td>
</tr>
<tr>
<td>T50%</td>
<td>-3.75±0.51a</td>
<td>-3.93±0.20a</td>
<td>-3.52±0.08a</td>
<td>-3.93±0.31a</td>
<td>-3.98±0.35a</td>
</tr>
<tr>
<td>T0%</td>
<td>-3.93±0.31a</td>
<td>-4.05±0.42a</td>
<td>-4.29±0.10a</td>
<td>-6.05±0.14b</td>
<td>-5.80±0.14a</td>
</tr>
<tr>
<td><strong>Chemlali</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T100%</td>
<td>-3.53±0.33a</td>
<td>-3.38±0.01a</td>
<td>-3.42±0.35a</td>
<td>-3.59±0.23a</td>
<td>-3.34±0.23a</td>
</tr>
<tr>
<td>T50%</td>
<td>-3.76±0.08a</td>
<td>-3.74±0.01a</td>
<td>-3.80±0.13ab</td>
<td>-3.75±0.07a</td>
<td>-3.63±0.07a</td>
</tr>
<tr>
<td>T0%</td>
<td>-4.08±0.57a</td>
<td>-4.00±0.01a</td>
<td>-4.13±0.24a</td>
<td>-4.34±0.27b</td>
<td>-4.54±0.27b</td>
</tr>
</tbody>
</table>

Effect of three water treatments on leaf Osmotic Adjustment (OA) and its components

Figure 1 (A&B) indicates that for Koroneiki plants, T50% plants show a very low osmotic adjustment (0.16 MPa) that decreases throughout the experiment. However, for Koroneiki T0% plants, the osmotic adjustment did not exceed 0.5 MPa, 21 days after applying water treatments. Then, it increases strongly by 85% and reaches 2.46 MPa, after 28 days of applying water treatments. At the end of the experiment, the osmotic adjustment of T50% and T0% plants reaches 0.08 and 2.02 MPa respectively. Chemlali plants, show a progressive increase of their osmotic adjustment throughout the experiment for both water treatments (50% AWC, 100% AWC). At the last day of the experiment, the osmotic adjustment of Chemlali T50% and T0% plants reaches 1.25 and 1.7 MPa, respectively.

Koroneiki plants T50% and T0% show a passive osmotic adjustment at 100% (Figure 1 C&D). However, Chemlali plants show an osmotic adjustment that is more active than passive. Our results confirmed the results of Boussadia et al. (2013) which mentioned that Koroneiki tends to adopt a passive strategy to tolerate progressive drought stress. Osmotic adjustment allows plants to tolerate temporary or prolonged periods of water shortage and is one of the crucial processes involved in plant adaptation to drought (Chaves et al., 2003).
Figure 1. Effect of water treatments on (A and B) leaf osmotic adjustment (OA, MPa) of olive tree (*Olea europaea* L. cv Koroneiki and Chemlali) during the experiment period. (C and D) leaf osmotic adjustment components (OA, AOA and POA; MPa) of olive tree at the 35th day after applying water treatments.

Effect of three water treatments on plant dry matter accumulation

The root/shoot ratio of Chemlali plants at T50% treatment was the highest (1.08) comparatively with the other two treatments (Table 2). This result shows that Chemlali plants valorize low quantities of water (T50%) rather than high quantities (T100%). However, for Koroneiki at T100% treatment plants show the best root/shoot ratio compared to T50% and T0%. This result seems to indicate that Koroneiki is more demanding in water than chemlali. The reduction of photoassimilates availability causes, at whole plant level, a change in the pattern of dry matter distribution: shoot growth will be inhibited while a higher quantity of assimilates will be transported and accumulated in the root system determining a higher root/shoot ratio in water stressed plants (Xiloyannis et al., 1999).

Table 2. Effect of three water treatments on the root/shoot ratio of olive tree (*Olea europaea* L. cv Koroneiki and Chemlali), 35 days after applying water treatment. Each value represents the mean ± standard deviation of three measures. The average of each value followed by the same letter do not differ statistically - SNK P <5%. The first letter is for the statistical analysis within the cultivar and the second is for the statistical analysis within the water treatment.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Water treatment</th>
<th>Root/shoot ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koroneiki</td>
<td>T100%</td>
<td>0.70±0.04**</td>
</tr>
<tr>
<td></td>
<td>T50%</td>
<td>0.61±0.02**</td>
</tr>
<tr>
<td></td>
<td>T0%</td>
<td>0.55±0.10**</td>
</tr>
<tr>
<td>Chemlali</td>
<td>T100%</td>
<td>0.70±0.07**</td>
</tr>
<tr>
<td></td>
<td>T50%</td>
<td>1.08±0.29**</td>
</tr>
<tr>
<td></td>
<td>T0%</td>
<td>0.79±0.13**</td>
</tr>
</tbody>
</table>

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References
Reducing the impact of drought by potassium application in olive trees (Olea europaea L.)

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Abstract:
For confronting the water scarcity various solutions were adopted particularly the regulated deficit irrigation. Despite its benefits this technique needs the good knowing of tolerant stages which affected by the climate change ie the blooming perturbation. In another way, it is known that potassium away from its action on fruit quality; it is involved in physiological processes by reducing transpiration and therefore maintains the cell turgor. This last feature was being exploited to our research objective. The present study aims the increase of water use efficiency in olive tree. The experiment consisted on the combination of the regulated deficit irrigation (RDI) and the potassium application. This is has been achieved in an olive orchard seven years old in the region of Sidi Bouzid located on the centre of Tunisia. Potassium treatments were 0%, 50%, 100% and 200% of olive tree needsand each one of them was subject to two water regimes (50%ETC and 100%ETC). The main results given that the 50%ETC irrigation regime combined with 50%, 100% and 200% potassium treatment slightly improved the water use efficiency. With these treatments the average yield was ameliorated. Also the olive maturity index was also increased.
Keywords: Olive, regulated deficit irrigation, potassium, yield, water use efficiency.
Introduction:

Olive tree (Olea europaea, L.) is the most cultivated crop in the Mediterranean basin. Tunisia is considered as one of the main olive producer. The majority of olive orchards are conducted as a rain fed system. With the increase of aridity due to the climate change olive production showed a great fluctuation. For confronting this matter, the modification of agronomic practices is necessary where many solutions were found such as the development of regulated deficit irrigation. Beneficial results were observed. Particularly, an increase of water use efficiency was noted (Wahbi et al., 2005; Dbara et al., 2016). On the other hand, the potassium element is involved in various physiological processes. It plays a key role in conferring abiotic and biotic stresses. In fact, it controls the stomata aperture and leaf transpiration by maintaining the cell turgor. Also, it was noted that potassium supplied to olive trees increased the water use efficiency (Abdolzadeh et al., 2009). In spite of its important roles, the potassium (K) has been given less attention than nitrogen (N) and phosphorous (P). For these reasons, the present work consists on the assessment of the combination of potassium nutrition and the regulated deficit irrigation applied on an olive orchard in an arid region of Tunisia.

Materials and methods:

1. Experimental site:

The experiment was carried on an olive orchard located in the Sidi Bouzid region (latitude 35°.04, longitude 9°.49). The arid climate characterizes this zone with an average precipitation less of 350 mm. The soil is sandy loam with a weak level of organic matter (0.23%). Trees were seven-year old of ‘Arbequina’ cultivar and received all horticultural management (drip irrigation, pruning,…).

2. Treatments:

Treatments consist on the combination of two water regimes (50%ETC and 100%ETC) and four potassium rates (0, 50, 100 and 200% of required rate). The ‘Solupotasse’ product was used for treatments (52%K₂O). Potassium application was done on soil divided on three times.

3. Measurements:

Yield, maturity index, oil content and shoot growth were evaluated for each treatment.

Results and discussion:

1. Yield:

The average tree production was slightly affected by treatments (Fig 1). Treatments 50%, 100% and 200% K even with 50%ETC increased yield. Differences between treatments were not statistically significant. For both water regimes, the potassium didn’t increased yield comparatively to control without potassium supply. This result is contradictory to those of Elloumi et al. (2009) and Inglese et al. (2002) which affirmed that potassium nutrition increased olive yield. Differences between results can be explained by the potassium application method. The foliar potassium spray appeared more efficient. Also, the soil texture seems affected the potassium nutrition.
2. Maturity index:
   The potassium increased the maturity index particularly with 50%ETC irrigation regime (Fig 2). The highest values were observed on 100%K and 200%K under water deficit regime (50%ETC). This is confirming the majority of previous researches which affirmed that regulated deficit irrigation enhanced olive maturity (Wahbi et al., 2005; Dbara et al., 2016). Equally, Faust (1989) affirmed that insufficient potassium concentrations decrease photosynthesis of leaves which in turn reduced sugar concentrations and fruit quality.

3. Oil yield:
   Similarly to MI, the oil content of olives increased with deficit irrigation independently to potassium rate (Table 1). This result was also confirmed previously. In fact, treatments without potassium showed the lowest oil content.

Table 1: Oil content for each treatment:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>100%ETC</th>
<th>50%ETC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%K</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>50%K</td>
<td>98</td>
<td>101</td>
</tr>
<tr>
<td>100%K</td>
<td>99</td>
<td>102</td>
</tr>
<tr>
<td>200%K</td>
<td>100</td>
<td>103</td>
</tr>
<tr>
<td>0%K</td>
<td>97</td>
<td>104</td>
</tr>
<tr>
<td>50%K</td>
<td>99</td>
<td>105</td>
</tr>
<tr>
<td>100%K</td>
<td>100</td>
<td>106</td>
</tr>
<tr>
<td>200%K</td>
<td>101</td>
<td>107</td>
</tr>
</tbody>
</table>
4. Vegetative growth:
The average shoot length was unaffected by potassium treatment but it is slightly limited by RDI (50%ETC) (Fig 3). In this way, Basile *et al.* (2003) affirmed that potassium deficiency negatively affected tree light interception and photosynthetic capacity in almonds tree.

![Figure 3: Average shoot length for each treatment.](image)

**Conclusion:**
Results highlighted the importance of potassium element especially in deficit irrigation conditions. In fact, an increase in yield, maturity index and oil yield was observed. However, the vegetative growth was unaffected.

**References:**


MODELLING OF CARBON FLUXES AND POOLS BETWEEN SOIL, VEGETATION AND ATMOSPHERE IN CROP FIELDS UNDER DIFFERENT AGRICULTURAL PRACTICES.

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\textsuperscript{4}University of Edinburgh

Abstract

Soil C sequestration in croplands has a number of advantages, both in terms of removing greenhouse gases (GHG) from the atmosphere and in terms of improving crop yields, water quality and reducing GHG emissions from croplands. In this communication, we use a crop model (DALEC-CROP) to investigate the fate of soil C in croplands under different management practices. We aim to track the evolution of soil C by ensuring that the model is able to track other C pools in the system using different sets of observations as additional constraints to the model. A Bayesian approach allows the use of heterogeneous sets of observations (such as ground measurements, C fluxes from towers and remote sensing observations from satellites) to be integrated to produce forecasts of different fluxes. We show that using a full set of observations results in the model representing daily fluxes reasonably well, and showing an adequate decrease of soil organic C (SOC). Soil respiration was however overestimated. Using only remote sensing data (which would allow application of this approach over larger areas) is shown not to provide enough constraint to the solution, and in this case, other sources of information would be necessary.
Introduction

The natural flow of carbon between land and atmosphere is regulated by the plants; the CO₂ is captured by photosynthesis into organic matter, storing the solar energy, and released back to the atmosphere following the process of organic matter oxidation derived from respiration and combustion (Houghton 2003). The amount of photosynthetic carbon fixed in the plants is defined as Gross Primary Production (GPP) and its estimation in croplands plays a crucial role in global carbon, water cycle and food security. GPP variation is affected by the region, the plant type and the physical and biochemical characteristics of the fields (Kalfas et al. 2011). In order the plant to take advantage of the stored energy for its maintenance and growth, the oxidation of organic matter is required and this process is defined as Autotrophic Respiration (Houghton 2003). The Heterotrophic Respiration, which is the decomposition of litter and organic matter by both the macro-organisms and microorganisms (Högberg et al. 2005), along with the Autotrophic Respiration, results in the total ecosystem respiration (Re). Finally, the Net Ecosystem Exchange (NEE) can be calculated by subtracting the total ecosystem respiration (Re) from the GPP, showing the net carbon transfer (Wattenbach et al. 2010).

Materials and Methods

Three crop fields’ sites selected at the University of Nebraska Agricultural Research and Development Center near Mead (Nebraska USA) with different cultivation management. The data used for the simulation of the three sites have been retrieved from the AmeriFlux database including atmospheric, plant and soil related measurements (AmeriFlux Network).

Table 1: Data provided for modelling

<table>
<thead>
<tr>
<th>Flux tower data</th>
<th>Other Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ concentration</td>
<td>Plant type</td>
</tr>
<tr>
<td>Temperature</td>
<td>Sown, harvest and tillage dates</td>
</tr>
<tr>
<td>Radiation</td>
<td>Leaf Area Index (LAI)</td>
</tr>
</tbody>
</table>
The model used to achieve the simulation is Data Assimilation Linked Ecosystem Carbon (DALEC-CROP) model used for the carbon cycle simulation providing a simple box model representation (Fig 1) of carbon pools connection and respiration fluxes (Sus et al. 2010, Revill et al. 2013).

![SPAc model representation with the carbon pool and fluxes](image)

The Bayesian approach updates initial estimates of DALEC-CROP parameters so that the different outputs of the model match observations (within the uncertainty of these measurements). In other words, we provide a set of parameters (and associated uncertainties) that result in the best model prediction of the observations. We start by setting DALEC-CROP parameters a prior distribution, assumed Gaussian, and solve for the posterior using a variational approach, which entails minimising the following cost function:

\[ J(\bar{x}) = \frac{1}{2} [M(\bar{x}) - \bar{y}]^\top C_{obs}^{-1}[M(\bar{x}) - \bar{y}] + \frac{1}{2} [\bar{x} - \bar{\mu}]^\top C_{prior}^{-1} [\bar{x} - \bar{\mu}] \]  

Where \( M \) is the DALEC-CROP model run with parameter vector \( x \), \( C_{obs} \) is the measurement uncertainty covariance matrix, \( y \) are the measurements, \( \mu \) is the model parameters prior mean, and \( C_{prior} \) is the model parameters prior covariance matrix. Eq. 1 is minimised using a gradient descent optimiser using finite differences.
Uncertainties (posterior covariance matrix of the parameters) are calculated as the inverse of the Hessian of J at the minimum point. Both model calibrations have been conducted using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) (Liu & Nocedal 1989). The two experiments constructed are:

- Calibration using all observations (LAI, the Rh and the AGB),
- Calibration using only LAI

Results and Discussion

The RMSE comparison between the calibration period 2002-2005 for the second site and the validation for the rest of the periods and sites show successful simulation of the NEE and GPP. It is observed in the Table 2 that the RMSE value of GPP in the second site (calibrated) is higher than the value of the first site and lower in the comparison with the third site. On the other hand, the NEE has lower RMSE in the second site with similar values in the third and bigger change in the first field due to underestimation of AGB for the maize period of cultivation that gives less litter and change the respiration rates. The water stress does not influence the NEE measurements because less GPP means less development, resulting to less autotrophic respiration (Verma et al. 2005). In general, the comparison between the second and third field indicates that irrigation is beneficial for the crop productivity.

<table>
<thead>
<tr>
<th>Site</th>
<th>flux</th>
<th>RMSE g C m⁻² d⁻¹ 2002-2005</th>
<th>RMSE g C m⁻² d⁻¹ 2006-2012</th>
<th>RMSE g C m⁻² d⁻¹ 2002-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NEE</td>
<td>1.69</td>
<td>2.65</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>GPP</td>
<td>1.48</td>
<td>3.0</td>
<td>2.56</td>
</tr>
<tr>
<td>2</td>
<td>NEE</td>
<td>1.56</td>
<td>2.47</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td>GPP</td>
<td>1.66</td>
<td>3.14</td>
<td>2.7</td>
</tr>
<tr>
<td>3</td>
<td>NEE</td>
<td>1.65</td>
<td>2.52</td>
<td>2.24</td>
</tr>
<tr>
<td></td>
<td>GPP</td>
<td>1.97</td>
<td>3.47</td>
<td>3.01</td>
</tr>
</tbody>
</table>

DALEC-crop model is able to represent the rotation management and simulate the NEE and GPP of the croplands but it is less successful in the soil due to lack of observations in the litter pool. Figure 2 below shows time series of NEE and GPP for the second field both for the observations and the model results. The model underestimates both the carbon sink and the carbon respiration mainly before and after the cultivation when the heterotrophic respiration is the main flux. In the calibration period (before blue line) the available measurements of the LAI show a
satisfactory comparison with the model results (Figure 2). On the other hand, Rh is underestimated in the middle of the cultivation period having simulation results with a maximum of 5 g C m$^{-2}$ d$^{-1}$. In addition, AGB is underestimated in the maize cultivation, influenced by the smaller LAI simulated values. SOM has been reduced as the simulation shows 15% change in ten years of intense cultivation.

Fig 2: Model (black) and observation values (red) for the second field for the period 2002-2005 for calibration (blue line marks end of calibration period) and validation.

The simulation of the system, using LAI only as constraint in the calibration, was unable to calculate the soil respiration due to the simplicity of the DALEC model in the soil functions and litter input in the soil system. The sudden input of the litter during the harvest period in combination with almost no litter input during the vegetation period, raise the soil respiration (quantified by the turnover rate) resulting to high error in the NEE (Fig 3) making mandatory to take into consideration the other observations.
Fig 3 Model calibration of NEE and GPP for the period 2002 – 2005 using only observation LAI in the cost function.

Acknowledgements

Site-specific climate and CO2 flux data are distributed by the AmeriFlux network (http://public.ornl.gov/ameriflux/)

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CONTRIBUTION TO THE SUSTAINABILITY OF SOLAR PHOTOVOLTAIC IRRIGATION SYSTEMS: AGRONOMY CASE STUDY

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²Faculty of Mechanical Engineering, University of Prishtina “Hasan Prishtina”, 10 000 Pristina, Kosovo, (corresponding author: shpetim.lajqi@uni-pr.edu)

Abstract: Usage of solar photovoltaic energy, not only in urban water supply systems, but also for irrigation has special importance for the entire human population on the world. Even if location has a sufficient quantity of water, it should be noted that electricity supply for its abstraction, further distribution and use can be a problem. Photovoltaic energy is particularly suitable for energy supply for irrigation in rural areas because there are locations where classical power network is not available or has limited availability. In this situation, especially in remote areas and on islands, Photovoltaic energy solves this energy and water distribution problem. Also, using of Photovoltaic energy contributes to the reduction of greenhouse gasses. In doing so, the emphasis is not only on the use of Photovoltaic energy, but also on improving of the performance of pumping stations and reservoirs, as well as the remaining parts of the water supply system. The abovementioned solution is sustainable, given the economic, environmental and social indicators, which is achieved by using original and innovative scientifically method, i.e. Critical Period Method. Critical Period Method includes design elements of the solution: Photovoltaic system, Pump station and Water reservoir based on the critical period of operation of each one. By using of solar photovoltaic energy, electric energy is produced and used for operational work of the pumping station. Pumping station pumps water into the water reservoir. From the water reservoir, water is distributed to the irrigation pipelines on the irrigation area. The balancing period of water pumping and water consumption (water and energy balance) is usually at least one day and may be several days, usually no more than five. Also, intention of this paper is to prove that the water reservoir with its usual hydraulic role of storing water also has the function of energy reservoir through the possible functional connection with the source of energy, which is in this case subsystem Photovoltaic. Such this kind of methodology so far hasn’t been applied anywhere in the world. Case study on the example of irrigation for agronomy purposes will present application of the mentioned method.

Key words: solar photovoltaic energy, irrigation, water pumping, rezervoir, agronomy, sustainability.

INTRODUCTION

Solar energy i.e. Photovoltaic (PV) technology is one of direct solar energy application and it directly converts solar energy to electrical energy (Muhsen et al, 2017). Photovoltaic water pumping system (PVPS) is one of the most important applications of PV in remote areas (Meah et al, 2008; Semaui et al, 2013). Low reliability and high initial cost are the main challenges to PVPSs (Meah et al, 2008).
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Thus, a proper sizing of PVPS is essential to fulfil the demanded water. Irrigation is a necessary part of human existence. Irrigation greatly facilitates the undertaking of a number of human activities. Nowadays, irrigation systems which use solar energy, i.e., solar photovoltaic energy, are quite often used in the field. Figure 1 shows a typical irrigation system, which uses PV energy. PV cells forms the PV generator. The PV generator is used for the conversion of solar radiation into direct current electricity which is then converted by an inverter into the alternating current which is necessary to drive the pump. Available insolation $E_s$, i.e., the electric energy $P_{el, PV}$ determines the appropriate uniform rate daily work period for the pumping station, $T_S$ (Borisov et al, 2016).

Figure 1. Common solar photovoltaic irrigation system (Borisov et al, 2016)

Pumping station pumps water into the water reservoir. From the water reservoir, water is distributed on the green areas. Such is a well-known and established technology, which is widely used. It should be noted that PV irrigation systems are often the only option for isolated and remote areas.

MATERIALS AND METHOD

The Critical Period Method (CPM) (Borisov et al, 2016; Đurin, 2014) encompasses all the design elements of the solution: the PV system, the pumping station and the water reservoir, and is based on the critical period of operation for each one. The balancing period is the period taken for water pumping and water reservoir water balance, $t_b$, is usually at least one day and may be several days, but is usually no more than five days ($t_b = 1$ to $5$ days). Based on the values obtained by the method, the minimum required size of the PV system is determined to provide the necessary inflow of water for the critical period. The minimum required $P_{el, PV}$ is determined from established differences $\Delta V_{t_b,i}$:

$$\Delta V_{t_b,i} = V_{PS, t_b,i} - V_{daily, t_b,i}$$

(1)

where $V_{PS, t_b,i}$ (m$^3$/day) is the daily amount of water pumped into the water reservoir over a certain time period (a day) $i$ and $V_{daily, t_b,i}$ is the daily amount of water required in a certain time period (a day) $i$. The critical day/period for the PV generator design is determined by statistical minimization, where $\Delta V_{t_b,i}$ is a difference which is typically equal to 0:

$$\min \Delta V_{t_b,i} \approx t^* \left( P_{el, PV, t_b,i} \right)$$

(2)
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The required volume for the water reservoir, $V$, is obtained using the common sizing procedures (Đurin, 2014). In general, the critical day/period for the design of the volume of the reservoir, $V$, is the day with maximum water demand and the shortest duration of solar radiation suitable for supporting pumping station operation, providing that on the available day insolation $E_{s(i)}$ is sufficiently high. Based on the above mentioned information, the required volume $V_{tb,i}^*$ for each alternative $t_b$ is obtained using statistical maximization, with the associated critical day. In other words, there is a need to calculate the biggest reservoir volume required for every day in the year:

$$V_{tb,i}^* \geq \max V_{tb,i} \Rightarrow t_{V, tb,i}$$  \hfill (3)

The same situation applies to the capacity of pumping stations $Q_{PS}^*$:

$$Q_{PS}^* \geq \max Q_{PS} \Rightarrow t_{PS, tb,i}$$  \hfill (4)

RESULTS AND DISCUSSION

Momentarily, there are a couple of possible locations for construction of the presented innovative irrigation system. But, most important and the biggest location is existing irrigation field at a location in Prapaqan, Municipality Deçan, Kosovo. Existing irrigation system consists of PV power plant with power of 3.0 kW (15 modules with 0.2 kW of peak power for each of them), water reservoir with capacity of the 500 m$^3$ and submersible water pump with power of 2.2 kW, Figure 2. With the listed main parts, irrigation system also includes all required equipment (concrete parts, pipelines, electronic and mechanical devices). Irrigation area has size of 8.9 ha (Lajqi et al, 2017).
Figure 2. Schematic representation of the irrigation system in Deçan, Kosovo

Figure 3 shows technical scheme of the described irrigation system.

There is a plan to upgrade existing irrigation field with regards to the economic and hydraulic requests by using of the CPM. Intention of this project is to prove that use of PV electric energy for the irrigation water pumping can contribute to the sustainability objectives of the rural areas.
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Figure 3. Technical scheme of the described irrigation system (modified from NSW Farmers, GSES, 2015)

REFERENCES
CERTIFICATION ORGANIC SNAI LS AND FUTURE MARKET-
CONSUMPTION EDIBLE SNA I LS

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Abstract

Eating snails was known from antiquity. Over the centuries, the consumption of snails remained low, due to their limited offer. The intensive consumption of snails began from the end of the 19th century, mainly due to the high promotion of their culinary traits. Nowadays, the snails are sought after by their devotees on all five continents to be used as food delicacies. (http://greeksnails.comlu.com). In Greece, snail-food consumption is not particularly popular with the exception of the island of Crete, where residents are more familiar with their consumption and the snails comprise one of their main dishes. Indeed, Cretans are considered world champions in snail consumption.

The breeding of snails for food is very widespread in France, where it is also in line with the dietary habits of the population and it is a process that can be profitable enough. Thus, it deserves to be treated with due professionalism and not to be exhausted in the logic of casual employment. Snails are considered as a highly valued food product, with continuously growing demand and guaranteed existing markets. Snails, belonging to the group of luxury foods like caviar, foie gras and truffles, have become relatively scarce and expensive (Karamani, E. 2014).

Keywords:
- Consumer's behavior, Thessaloniki, snails consumption, biological heliciculture,
  Categorical regression

1. Introduction

Eating snails was known from antiquity. Over the centuries, the consumption of snails remained low, due to their limited offer. The intensive consumption of snails began from the end of the 19th century, mainly due to the high promotion of their culinary traits. Nowadays, the snails are sought after by their devotees on all five continents to be used as food delicacies. (http://greeksnails.comlu.com). In Greece, snail-food consumption is not particularly popular with the exception of the island of Crete, where residents are more familiar with their consumption and the snails comprise one of their main dishes. Indeed, Cretans are considered world champions in

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snail consumption. The breeding of snails for food is very widespread in France, where it is also in line with the dietary habits of the population and it is a process that can be profitable enough. Thus, it deserves to be treated with due professionalism and not to be exhausted in the logic of casual employment. Snails are considered as a highly valued food product, with continuously growing demand and guaranteed existing markets. Snails, belonging to the group of luxury foods like caviar, foie gras and truffles, have become relatively scarce and expensive (Karamani, E. 2014).

1.1. Consumer attitude towards organic food

More and more consumers are worried about pesticide residues on the food they consume. At the same time, the countryside and the environment are being destroyed by modern forms of agriculture. The interest in organic products, however, was rekindled when some researchers (Thompson and Kidwell, 1998) dealt with whether pesticide residues found in baby foods targeted at young children were within the allowed limits. However, the number of consumers in each country who are aware of organic food is the result of the nutritional development of the organic market in each country and the particular marketing strategy followed. For example, in Turkey (Rundgren, 2000) only 9% of the population is aware of the existence of organic products, while in Greece (Fotopoulos and Krystallis, 2002) 81.5% of the population is informed.

Different surveys (Wandel and Bugge, 1997) have shown that the main reasons that lead consumers to the organic market are that they are not used for their production, they are more nutritious and healthier and have a richer taste and flavor. On the contrary, their high price, their inappropriate visibility, and their availability from a limited number of stores, are the main reasons for consumers. Another research (Gil et al., 2000), conducted in Spain, found that consumption of organic products is directly relevant to the consumer for the protection of the environment. This means that people who are interested in healthy diets are usually those who manifest and have a particular interest in ecological issues. It should be noted here that according to the survey, these consumers are willing to spend even more quantities to secure organic-food.

In a survey conducted in Denmark (Grunert and Juhl, 1995), with the cluster analysis technique, the sample of consumers is divided into three categories: organic buyers, occasional buyers and regular buyers. research has shown that those with strong ecological interests are more likely to buy organic products.

Therefore lifestyle and consumer attitudes towards ecological issues should be the subject of research when organic marketing strategies are organized.

2. Purpose and specific objectives of the survey

with the review of the literature on organic food carried out above, it was realized that there is a correlation with the consumption of snails.
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Thus, we report that the purpose of this research is to investigate the behavior of consumers, the potential and the prospect of promotion in edible snails in Greece.

In particular, the research objectives are:

1) Study whether consumers will consume organic snails in the future.

2) Exploring the correlation between consumer tastes in processed and non-snail products with the following characteristics: a) Demographics (sex, age, marital status) b) Geographical (area of residence) and c) Socio-economic level, income)

3) Identify the points where consumers are supplied with snails, whether they are shops or nature.

3. Research Methodology

The quantitative survey was carried out based on raw data that were collected with the aid of a questionnaire. This questionnaire was completed by consumers residing in the city of Thessaloniki in a time framework from December 13, 2013 up to April 28, 2014. The questionnaire was the type of self-management questionnaire (Siardos, 2009, p. 165), that is to say it was presented to the respondents with its purpose explained, it was left to the respondents to answer it themselves and then it was received back completed.

The sampling frame was about constructing and collecting the names of members (statistical units) of the population from which the sample was taken. So, while in a general survey this construction is not necessary for the taking of the sample, yet it is considered essential in limited surveys. Searching for a suitable sampling frame, the concern of researchers is to find one that responds to the particular purpose of their research. So, they must include all the elements of the population that are of interest to them and exclude those that do not serve that purpose (Siardos, 2009, pp. 78-79).

In this research, the planning maps with building the blocks of the seven municipalities of the urban complex of Thessaloniki were considered as a sampling frame. Also, for the determination of the total population of the area under study interim results of the 2011 population census were used. The population census was conducted by the Hellenic Statistical Authorities (EL.STAT.). According to these results, 819,770 inhabitants live in the urban complex of Thessaloniki and are distributed as follows: (a) Municipality of Thessaloniki: 322,240 inhabitants, (b) Municipality of Kalamaria: 91,270 inhabitants, (c) Municipality of Neapoli - Sykies: 84,500 inhabitants, (d) Municipality of Pavlos Melas: 98,870 inhabitants, (e) Municipality of Kordelio - Evosmos: 101,010 inhabitants, (f) Municipality of Ampelokipoi - Menemeni: 51,670 inhabitants and (g) Municipality of Pilea - Hortiatis: 70,210 inhabitants (Source: http://www.statistics.gr)
4. Results

Conclusions of descriptive statistics

To the question "Would you buy organically bred snails" 57.2% of the answers were negative and 42.7% were positive. This is because consumers have linked organic products with healthy food and for this reason they show greater preference even in new concepts such as the concept of “organic snail farming”.

The innovative idea of biological snail farming reinforces the new Common Agricultural Policy (CAP) which now puts emphasis on rural development and on disciplines of alternative agriculture, with a particular focus on the sustainable development and the protection of the environment by shifting to organic farming in the first place and to crops that are not only dynamic but can also be biological.

To the question “Do you buy snails from delicatessen stores” 91.5% responded “no” and 8.5% responded “yes”.

Similarly, to the question “Do you buy snails from producers in the farmer’s markets”, 75.4% answered “no” and 24.5% answered “yes”, which is also the largest percentage that responded positively from the total. Thus, it is concluded that the consumers that had taken part in the survey were purchasing their snails from farmer’s markets in the first place.

Finally, there was the option "I do not buy them" added and the 62.3% responded positively because they collected their snails from nature, and 37.7% of those asked stated that they buy their snails.
4.1 Conclusions of categorical regression

The results of the regression analysis for each of the dependent variables in the sample survey are then presented and interpreted. For research purposes and depending on the nature of each dependent variable, they are divided into three groups:

1) With the dependent variable "I have tried snails"
2) With the dependent variable "I buy snails"
3) With the dependent variable "I will continue to buy snails"

And independent variables the demographic traits

The estimation of the contribution of the independent variables on the interpretation of the dependent ones will significantly help to determine those factors that make consumers want to taste the product and then buy it or buy it in the future, so that there is an assessment of the model's proper adaptation to the survey data.

i) "I have tried snails"

Only three variables (age, income, number of family members) significantly interpret the dependent variable “I have tried the snails”. All the three variables together cumulatively interpret 68.5% of the dependent variable.

ii) “I buy snails”

The four variables (age, occupation, income, number of family members) significantly interpret the dependent variable “I buy snails”. All the four variables together cumulatively interpret 86.5% of the dependent variable.

iii) “I will continue to buy snails”

The four variables (sex, age, occupation, number of family members) significantly interpret the dependent variable "I will continue to buy snails”. All the four variables together cumulatively interpret 89.8% of the dependent variable.
5. Suggestions

In accordance with the findings of this research, it is implied that consumers are concerned not only about the nutritional value of the food and the conditions of its production but also about the quality of the food they eat. Nonetheless, information on snails and their nutritional value is incomplete. Hence, it is suggested that: 1) Biological snail farming is established. 2) Mechanisms are developed with the aim of safeguarding and stabilizing the quality, such as the certification of product quality by competent bodies. 3) Snail-food is better promoted as product through advertising
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methods so that consumers are better informed about the nutritional value of it and its general benefits to humans.

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Modeling maize production in limited irrigation conditions, for sustainable water use
Climate Changing Agriculture

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Abstract

Modeling climate change, for future conditions, shown higher temperature and very significant lower precipitation during April – September growing season, especially during summer months June, July and August. In previous research, simulated maize production (April – September growing season) using DSSAT crop model, in non irrigated conditions and with 180 mm water added per growing season, in 2030 and 2050 year, shown very significant lower yield results. As an adaptation measure, in crop model, irrigation was set on 50 – 60% available water in our climate and soil conditions. Those new conditions, using crop model, gave high yields according to 1971-2000 period, but the effective irrigation was significant higher. In this study, it was chosen Rimski Sancevi location in Northern part of Serbia, Vojvodina province, because it is favorable agricultural area, with great agroclimatic and soil chernozem potential to estimate lower effective irrigation in maize production. For 2030 and 2050 year, as a measure for sustainable water use, irrigation was set for 15% lower, on 35% available water, in DSSAT crop model. The results shown high yield. In a comparison with yield under 50% available water, for Rimski Sancevi location, yield was high and effective irrigation was less for one to two treatments per growing season (about 23 to 35 mm). On the base of yield results, it is concluded that maize production, on Rimski Sancevi location, is expected to be high in future climate conditions under lower effective irrigation management of 35% plant available water.

Key words: climate change, DSSAT crop model, maize yield, effective irrigation, water conservation

Introduction

Maize is a very favorable crop in human and animal consumption. In Serbia, it is usually produced in non irrigated conditions during spring and summer months. In climate projections for future conditions, during April – September period, higher temperatures and lower precipitation are expected. These two parameters are most limited factors in crop production (Olesen et al, 2011). In June – August period, for 2030 year is expected higher temperature for 1.3 °C and for 2.9 °C in 2050, while the precipitation is expected to be lower for 22.7% in 2030 year and for 42.4% in 2050 year (Jancic et al., 2015, Jancic, 2017).

In previous research, using DSSAT crop model, the maize yield results shown very significant lower yield in non irrigated production and with 180 mm added water per growing season (Jancic, 2016a, b). As an adaptation measure, the irrigation in DSSAT crop model was fixed on 50 – 60% of plant available water (Hoogenboom et al, 2012). The results shown high yield, but the model gave a significant higher effective irrigation according to 1971-2000. The aim of this research was to keep high production but in limited water conditions, for sustainable water use. As a favorable agricultural area, with great agroclimatic and soil chernozem potential, Rimski
Sancevi was chosen for an field experimental location. The simulations of maize production were done using DSSAT 4.2. crop model, because it has a possibility to fix the irrigation on precise percent of available water. The irrigation was fixed on 35%, 15% less available water and all other parameters and crop management was the same as in previous research.

Materials and Methods

Climate and soil data

The daily weather data for current period (1971-2000) were observed from Rimski Sancevi weather station, located in northern part of Serbia (latitude 45° 20’ N, longitude 19° 51’ E, altitude 84 m). The data set included: maximum and minimum temperature, solar radiation, precipitation, wind speed and vapour pressure. For future conditions, for 2030 and 2050, our results from ECHAM climate model (Roerckner et al. 2003) under A2 scenario were statistically downscaled with Met and Roll weather generator. In all simulations CO₂ effect was considered. In 2030 year CO₂ concentration was set on 454 ppm and 532 ppm in 2050 year (IPCC, 2001). The soil data were measured on experimental field included: mechanical and chemical characteristics (Jancic, 2016a). The soil type was described as chernozem by WRB classification 2007 (www.fao.org./ag/agl/agll/wrb/doc/wrb2007_corr.pdf).

Crop management and model

An experimental field was set on Institute for Field and Vegetable Crops from Novi Sad. The experiment was conducted from 1997 year to 2004 year (Pejić et al., 2009). Sowing occurred on 20 April 1997 and harvest was on 14 September 1997. The production was organized in non irrigated conditions and with 180 mm added water per growing season. Crop management was standard and usually in our climate and soil conditions (Jancic, 2016b). DSSAT crop model (Tsuji et al., 1998) was used as a tool for maize production simulations. The model has an opportunity, to adjust and fixed water availability. When soil water content is below selected percent of plant available water, in that moment model added necessary water to crop. In this research the plant available water was set on 35%.

The results are presented as relative change in yield for 2030 and 2050 year according to 1971-2000 period and absolute change in effective irrigation according to current period.

Results and Discussion

Climate change impact on yield and net irrigation in limited irrigation condition

Using the same data for future climate conditions, crop management and genetic parameters from previous research for maize production simulations (Jancic, 2016b) in non irrigated, 180 mm added water per growing season and 50% available water conditions, the model for 35% available water conditions gave the next results: the maize yield was high, 12.27 t/ha in 2030, and 12.02 t/ha in 2050 year. The relative change in yield for 2030 was -1.2% and -3.2% for 2050 year according to 1971 – 2000 period yield. The average effective irrigation for 1971-2000 was 210.67 mm per
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growing season. The results shown higher effective irrigation for 44 mm in 2030 and for 75 mm in 2050 year according to 1971-2000 period. It is necessary to say that effective irrigation results shown less irrigation for one to two treatments (23 to 35 mm), in our conditions, according to 50% available water conditions.

Conclusions

- It is expected higher air temperature for 1.3 °C in 2030 year and for 2.9 °C in 2050 year.
- The precipitation is expected to be lower for 22.7% in 2030 year and for 42.4% in 2050 year.
- The maize simulations under 35% available water condition gave high yield results (12 t/ha) for 2030 and 2050 year.
- The effective irrigation was lower for two treatments according to effective irrigation under 50% available water.

On the base of simulation results it is concluded that maize production under 35% available water condition should benefit in future climate conditions. The yield is expected to be high and effective irrigation lower. It is important to estimate impact of limited irrigation conditions on crop production, because the water is limited natural resource, and simulations are especially important for fundamental grain crops and also for vegetable crops which have higher water demands and are less morphology developed and prepared for drier expected conditions. Crop models are, in this moment, the only tool which may be used to estimate sustainable water use in expected climate change conditions.

Acknowledgements

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Author Milena Jancic Tovjanin is grateful dr Branislava Lalic for weather data downscaling with Met & Roll weather generator.

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A COMPARATIVE ESTIMATION OF CLIMATE CHANGE IMPACTS ON COTTON AND MAIZE IN GREECE
Climate Changing Agriculture

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2: Research Centre of Atmospherics Physics and Climatology, Academy of Athens, Greece, 
3: Navarino Environmental Observatory, Greece

Abstract

The impact of climate change on cotton and maize was estimated on the basis of three IPCC Emission Scenarios (A1B, A2, B2). The study focused on seven areas (Agrinio, Alexandroupolis, Arta, Karditsa, Mikra, Pyrgos, Yliki) during three periods, 1961–1990, 2021–2050 and 2071–2100. Eight climatic models were used for the analysis of the A1B Scenario, while three models were applied for the A2 and B2 scenarios respectively. FAO’s AquaCrop model was applied as a crop simulation tool. On the account of their function coefficients, all climate models were assessed on the basis of their discriminant ability regarding the seven areas. For the scenario A1B, the regions of Western Greece (Arta, Agrinio, Pyrgos) exhibited the most favorable results in comparison with the other regions. This tendency became more pronounced towards the end of the century. No significant differentiation among the areas was observed in the A2 scenario. A positive change for all regions was observed for scenario B2. In maize, the scenario A1B produced small changes in yields, which did not exceed 5%. The scenario B2 gave more optimistic estimates of yield changes towards the end of the century in comparison to the scenarios A1B and A2.

Keywords

Cotton, Maize, AquaCrop, Climate Change, Discriminant Function Analysis, Greece

Introduction

Arable crops in Greece cover almost 55% of the cultivated land (ELSTAT, 2014). Greek cotton represents more than 80% of the total E.U. production (European Commission, 2017) while maize accounts for 17% of the arable crops cultivated area.

The recent findings of the Intergovernmental Panel of Climate Change (IPCC) reveal, especially for the Mediterranean region where Greece is located, that the duration and intensity of droughts will increase and will be accompanied by significant reductions in summer soil moisture and temperature increase (Kovats et al, 2014). Moreover, an integrated national study regarding the impacts of climate change on agriculture showed that in some cases arable crops yields are significantly vulnerable to water stress, temperature increase and soil degradation (Bank of Greece, 2011).

As a result estimating the impacts of climate change on cotton and maize yields for 2021-2050 and 2071-2100 is the main aim of this study.

Materials and Methods

Seven areas (from North to South: Alexandroupolis, Mikra, Karditsa, Arta, Agrinio, Yliki, Pyrgos) representing the most important cotton and maize cultivation zones of the Greek mainland were selected for this study.
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For the projection of climate change conditions three Emission Scenarios (A1B, A2, B2) as they were developed in the third IPCC report were used (Nakićenović et al., 2000). Each Emission Scenario was simulated by several climate models providing information for minimum and maximum temperature, relative humidity, rainfall, solar radiation and wind speed on a daily basis for the periods 1961-1990 (reference period), and 2021-2050, 2071-2100 for A1B scenario while for A2 and B2 the respective time period was 2071-2100 only.

The AquaCrop crop growth simulation model (Raes et al, 2009, Steduto et al, 2009) was used to project the yield productivity taking into account the variability of the climatic parameters of the climate models and the increase in CO₂ concentration of each Emission Scenario. The evaluation of the model simulation under real conditions was performed with the Root Mean Square Error (RMSE) (Stricevic et al., 2011; Hussein et al., 2011) and index of Agreement (d) (Willmott, 1982) equations.

Finally the stepwise discriminant function analysis (SDFA, Jennrich, 1977) was used for assessing climate model's ability to differentiate the simulated cotton and maize yields among the study areas.

Results and discussion

AquaCrop was firstly calibrated and validated for both cotton and maize using experimental data from Karditsa (2005, 2006, 2007) and AUA (2010, 2011) fields respectively. In both cases the crop model's simulated production in terms of yield and biomass were close to the observed values (Table 1).

Table 1: Statistical comparison between simulated and observed yield and biomass for cotton and maize

<table>
<thead>
<tr>
<th></th>
<th>Cotton</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield</td>
<td>Biomass</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.17</td>
<td>0.49</td>
</tr>
<tr>
<td>d</td>
<td>0.94</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Simulated cotton yields derived through AquaCrop for the A1B scenario produced for some climate models quite erratic results. For example, HadRM3 model predicted a decrease of 102% in Ylikii for 2100 while, at the other end, CNRM model projected a 43% increase.

On the other hand, AquaCrop's projected outcome for maize was characterized by smaller yield fluctuations.

The efficiency of the climate models for yield prediction in the seven examined areas was assessed using the SDFA by comparing their function coefficients over the seven sites. This analysis showed that in the case of cotton C4I and DMI-HIRHAM models played consistently the most significant role in the discriminant process for the three periods (Table 2), while in maize C4I and REMO-MPI discriminated in a better way respectively (Table 3).

Table 2: Standardized discriminant function coefficients for the three periods in the case of A1B cotton simulation

<table>
<thead>
<tr>
<th>Models</th>
<th>1961-1990</th>
<th>2021-2050</th>
<th>2071-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standardized</td>
<td>Standardized</td>
<td>Standardized</td>
</tr>
<tr>
<td>func 1</td>
<td>func 2</td>
<td>func 1</td>
<td>func 2</td>
</tr>
<tr>
<td>HadRM3</td>
<td></td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Models</th>
<th>1961-1990</th>
<th>2021-2050</th>
<th>2071-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4I</td>
<td>0.569</td>
<td>-0.504</td>
<td>0.556</td>
</tr>
<tr>
<td>REMO-MPI</td>
<td>0.328</td>
<td>0.608</td>
<td>0.383</td>
</tr>
<tr>
<td>CNRM</td>
<td>0.176</td>
<td>0.527</td>
<td>-0.36</td>
</tr>
<tr>
<td>DMI-HIRHAM</td>
<td>0.454</td>
<td>-0.118</td>
<td>0.456</td>
</tr>
<tr>
<td>KNMI</td>
<td>0.397</td>
<td>0.185</td>
<td>0.383</td>
</tr>
<tr>
<td>SMHI</td>
<td></td>
<td></td>
<td>0.598</td>
</tr>
<tr>
<td>ETHZ</td>
<td>0.526</td>
<td>0.161</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Standardized discriminant function coefficients for the three periods in the case of A1B maize simulation

In the case of the B2 scenario the SDFA procedure showed that no significant difference among the three climate models was indicated for both cotton and maize yield simulations. In the A2 scenario, the SDFA statistics revealed that DMI-HIRHAM and SMHI climate models exhibited the higher function coefficients in maize (Table 4). However, cotton simulations through the SDFA process did not show any significant difference for climate models.

Table 4: Standardized discriminant function coefficients for the periods 1961-1990 and 2071-2100 in the case of maize simulation for the A2 scenario.

<table>
<thead>
<tr>
<th>Models</th>
<th>1961-1990</th>
<th>2071-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized</td>
<td>Standardized</td>
<td>Standardized</td>
</tr>
<tr>
<td>func1</td>
<td>func2</td>
<td>func1</td>
</tr>
<tr>
<td>HadRM3</td>
<td>0.013</td>
<td>0.093</td>
</tr>
<tr>
<td>C4I</td>
<td>0.08</td>
<td>0.363</td>
</tr>
<tr>
<td>REMO-MPI</td>
<td>1.116</td>
<td>0.601</td>
</tr>
<tr>
<td>CNRM</td>
<td>0.587</td>
<td>-0.743</td>
</tr>
<tr>
<td>DMI-HIRHAM</td>
<td>-0.329</td>
<td>0.266</td>
</tr>
<tr>
<td>KNMI</td>
<td>-0.417</td>
<td>-0.459</td>
</tr>
<tr>
<td>SMHI</td>
<td>0.115</td>
<td>-1.006</td>
</tr>
<tr>
<td>ETHZ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to these findings a spectrum of minimum and maximum yield change values was developed for each case. For cotton, the final simulation results for the A1B scenario revealed a positive impact of climate change on seedcotton yields in the areas of Western Greece (Agrinio, Arta, Pyrgos) and negative impacts or great fluctuations in the other areas (Table 5).

Table 5: Comparison of seedcotton maximum and minimum yield change in the seven study areas during 2021-2050 (left) and 2071-2100 (right) as percentage of the reference period 1961-1990 according to the climate models C4I and DMI-HIRHAM for the A1B scenario.
When comparing the A2 and B2 scenarios, a tendency for higher seedcotton yield changes was found in A2, except the area of Alexandroupolis. In addition, the difference between minimum and maximum values was lower in the B2 scenario than in A2 (Table 6).

Table 6: Comparison of seedcotton maximum and minimum yield change in the seven study areas during 2071-2100 for the A2(left) and B2(right) scenarios as percentage of the reference period 1961-1990.

Accordingly, in the case of maize AquaCrop’s results showed smaller yield changes ranging from -20% to +6% compared to cotton (Tables 9,10). Especially for the A1B scenario a stronger negative impact is expected closer to 2100 than in 2050 and at the same time western areas (Pyrgos, Agrinio, Arta) seemed to be more favored (Table 7).

Table 7: Comparison of maize yields change maximum and minimum yield change in the seven study areas during 2021-2050 (left) and 2071-2100 (right) as percentage of the reference period 1961-1990 according to the climate models C4I and REMO-MPI for the A1B Scenario
Moreover, B2 scenario had a more positive impact on maize yields than in A2 for all the examined areas. In the case of A2 it seems that northern areas (Alexandroupolis, Mikra) and northwestern areas (Arta) to be more favored (Table 8)

Table 8: Comparison of maize maximum and minimum yield change in the seven study areas during 2071-2100 for A2(left) and B2(right) scenarios as percentage of the reference period 1961-1990.

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PHYSIOLOGICAL COMPARATIVE STUDY OF HALOPHYTES AND GLYCOPHYTE FOR ADAPTATION TO MEDITERRANEAN SALINE COASTAL AREAS
Climate Changing Agriculture

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Abstract

In the current study, four species contrasting in salt resistance were used to test their differential response in relation to their availability to scavenge Na+ and accumulate C. Atriplex halimus as a xero-halophyte plant; Salicornia europea an euhalophyte; Cakile maritima a halophyte and Brassica rapa a glycophyte, were treated with NaCl (0, 100, 200 and 300 mM) in a hydroponic cultivation. A full valuation of the effect of salinity on the leaf succulence (Ls) and leaf thickness (LT) was performed, in addition to the relative growth rate (RGR), Na+ concentration and C and N assimilation. RGR was enhanced by salinity in Atriplex and Salicornia species in consonance with their higher Ls that was related to water content and Na+ accumulation in the plants. Cakile was able to maintain its stable water content during different NaCl concentrations but RGR was decreased. An increased and coordinated carbon and nitrogen assimilation may be responsible for halophyte plant adaptation. Thereby, our results suggest that both Atriplex and Salicornia were able to accumulate until 15g and 11g Na/100g leaf respectively and present an optimal growth at 100 and 200 mM NaCl. They could make full use for C fixation in marginal salty environments defining the possibility of a saline agriculture.

Keywords: Atriplex halimus, Brassica rapa, Cakile marítima, Carbon assimilation, Leaf Succulence, Salicornia fruticosa, Salinity

Introduction

Natural and environmental resources have been overexploited during the last years and numerous environmental constraints have affected the production of agricultural crops (Pooja and Rajesh, 2015). Amongst these, soil salinity is one of the most destructive environmental stresses and one of the main impacts of climate change. The only way to cope with this situation would be to conceive appropriate mechanisms that can lead to the conservation of these resources. Thus, salt tolerance is an important crop attribute that needs attention among scientists worldwide. Halophytes are extremophiles that may tolerate salinity levels toxic to the most plants and it depends on the ability to regulate the internal salt concentration and prevent ions from reaching toxic levels. Some halophyte plants develop different mechanisms to handle stress such as salt secretion through leaf glands, succulence, and relocation of salt to other organs affecting C and N assimilation rates in the plant (Sobrado 2001; Debez et al., 2006).
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From an applied point of view, it is important to identify halophytic genotypes and the suitable conditions for maximizing their yield through an understanding of the mechanisms to tolerate salt stress, selecting those with agronomic traits on salt tolerance for establishing bases of a saline agriculture since they are a good alternative to conventional crops, not only for food production but also for bio-fuel, fodder, fibres, and essential oils (Lokhande and Suprasanna, 2012).

Material and Methods

In this study we chose four plants which differ by them response to salinity. Two Amaranthaceae, *Atriplex halimus* and *Salicornia fruticose* (provided by Viveros Muzalén S.L., Murcia, Spain), and two Brassicaceae, *Cakile maritima* (collected from Raouded, 20km North of Tunis, Tunisia) and *Brassica rapa* (provided by Sakata Ibérica S.L., Valencia, Spain). Plants were grown in controlled environmental chambers in Hoagland’s solution (Hoagland and Arnon, 1950) and treated with NaCl (0, 100, 200 and 300mM NaCl). Salinity was applied during one month and all the experiments involved at least five independent replicates.

The relative growth rate (RGR) in whole fresh plant (g·g⁻¹ DW·d⁻¹) was determined by the following equation; RGR = (log FW2-logFW1)/ (t2-t1) and the tissue water content (TWC) was expressed by g·g⁻¹ DW and calculated as follows: TWC% = (FW-DW)*100/FW.

The concentration of Na⁺ was analyzed in lyophilized leaf tissue using a Perkin–Elmer (Waltham, MA) 5500 model ICP emission spectrophotometer. Leaf succulence (Lₛ) and leaf thickness (Lₜ) were estimated as describe Debez et al., 2008. Finally, the total carbon and nitrogen contents were analyzed in leaves and roots using a CN analyzer (Thermo-Finnigan 1112 EA elemental analyzer; Thermo-Finnigan, Milan, Italy).

Results and discussion

Relative growth rate (RGR) marked differences in the plant response to salinity (Fig. 1). A salt-induced growth has been previously described in obligatory halophytes (Abdulrahman and Williams, 1981) and according to this, in our study, *Atriplex* and *Salicornia* showed an optimal growth at moderate salinity. However, in *Cakile* and *B. rapa* RGR values were higher at all NaCl concentrations. This fact could be related to their life cycle, genotypic traits associated to the start of vegetative growth or domestication (Debez et al., 2013).

![Figure 1. Relative growth rate (g g⁻¹ FW) of *Atriplex halimus* (A.h), *Salicornia fruticose* (S.f.), *Cakile maritima* (C.m.) and *Brassica rapa* (B.r.) control plants and plants treated with 100, 200 and 300 mM NaCl for one month.](image-url)
Leaf succulence ($L_s$) was increased by salinity in *Atriplex* and *Salicornia* in consonance with their higher water content and Na$^+$ accumulation (Fig. 2A). By contrast, it was decreased in *Cakile* and *B. rapa*. Either of them was able to incorporate more than 8g Na/100g leaf. But *Atriplex* and *Salicornia* were able to accumulate until 15g and 11g Na/100g leaf respectively.

**Figure 2.** Leaf succulence ($L_s$) (A) and leaf thickness ($L_T$) (B) of *Atriplex halimus* (A.h), *Salicornia fruticose* (S.f.), *Cakile maritima* (C.m.) and *Brassica rapa* (B.r.) control plants and plants treated with 100, 200 and 300 mM NaCl for one month.

In *Atriplex*, at 300 mM, a decreased $L_T$ and a highest Na$^+$ accumulation (Fig. 2B) could be due to the salt excretion once salinity reaches a leaf threshold for vacuoles accumulation (Ben Hassine et al., 2008). But in *Salicornia*, decreased $L_T$ at 300 mM NaCl was associated to less Na$^+$ content in the leaf tissues than at 200 mM NaCl. Thus, a mechanism of Na$^+$ exclusion at root membrane level could not be discarded although in, both, *Atriplex* and *Salicornia* reduced biomass (data not shown) at 300 mM NaCl.

The highest N and C content were observed in the leaf tissues of *Atriplex* and *Salicornia* at 100 and 200 mM NaCl (Fig. 3). A best C fixation linked to a better photosynthesis, improved plant growth (Chakrabarti et al., 2003). It has been recognized that a better coordination of C and N assimilation could also facilitate proteins synthesis and other metabolic process (Fan et al., 2011) that will be responsible for halophyte plant adaptation.
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Figure 3. Carbon (A) and N (B) concentration in the leaf tissue of *Atriplex halimus* (A.h), *Salicornia fruticose* (S.f.), *Cakile maritima* (C.m.) and *Brassica rapa* (B.r.) control plants and plants treated with 100, 200 and 300 mM NaCl for one month. In conclusion, leaf succulence and C assimilation might be more accurate to growth and salt-tolerance in halophytes than in glycophytes under salt stress, allowing the use of these plants for soil Na⁺ sequestration and C fixation in saline environments.

Acknowledgements

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THE OLIVE GROVE A TOOL TO DEVELOP MITIGATION STRATEGIES TO CLIMATE CHANGE
Abstract

Mediterranean Ecosystem was defined during 70s of last century for Mitrakos, Money, Montenegro, Fuentes…, which characterized for some soil and environmental conditions, that promotes important adaptations of vegetation as sclerophyllous traits. Under Mediterranean and in semiarid environmental conditions, more than 440 mm of annual rainfall are required for oaks forests to persist. Summer drought and winter cold are thus important abiotic factors limiting the distribution of oak species and fosters the development of shrub and secondary tree communities, mostly pine. In both cases, drought stress is involved. Olive groves have been, are and will be an important option in Mediterranean, semiarid and arid areas of the world in order to provide food, ecosystemic services, landscape, culture and population stabilization, similarly, this crop avoid fire risk, erosion and desertification. Under these environmental and cultural conditions this crop is a real carbon sink by means of management in woody parts of plants and soil. So, in Catalonia (North East of Iberic Peninsula) carbon stock in an olive grove is close to 92 Mg or tons /ha in woody part of plants, besides, to this amount about 40 tons of the carbon in the soil can be added. This values of carbon stock in wood are between the 107 Mg C/ha of an Abies alba forest and the 28 Mg C/ha of a Pinus halepensis community. This important carbon stock can be developed according 4x1000 strategy and conservation agricultural practices, in this way, olive groves are not the solution, but they are one of the real solutions against climate change in Mediterranean and semiarid conditions.

Key words

Climate change, mitigation, carbon sink

Introduction

Climate change is and will be for a long period of time and therefore, will generate many, important and profound changes.

The scientific evidence (IPCC 2014) certifies it at a global level and assessments of the historical climate and projections regarding it are also confirmed locally (see SMC 2014 and 2015 in TICCC 2016).

However, it has been evaluated in many situations as a simple cause-effect relationship and this is more complicated due to different space time interactions among different components of ecosystems, which promotes synergetic and / or
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Contrary effects. Also, it must be taken into consideration the great importance of regionalization of climate change projections and effects, because in some cases local areas suffer additive stresses, as drought in Mediterranean Basin and in arid and semiarid areas of the world. The Mediterranean ecosystem is characterized by a double stress, cold / drought (Terradas and Savé 1992) and to powerful climatic phenomena such as the North Atlantic Oscillation (NAO), oscillates from the Western Mediterranean (WeMO) and Arctic oscillation (AO) (Lopez - Bustins et al., 2008).

At the regional level, at a reduced geographical scale, the forecasts of the Third Report on Climate Change in Catalonia (http://cads.gencat.cat/ca/detalls/detallarticle/Tercer-informe-sobre-el-canvi-climatica-Catalunya-00003, TICCC, 2016) are fully aligned with the Report of the International Panel of Experts on Climate Change (IPCC, 2014) and the Meteorological Service of Catalonia (SMC, 2015) are that the average temperature can increase up to 0.8 ºC for the period 2012 to 2021, on those registered in the period 1971-2000, or 1.4 ºC for the period from 2031 to 2050.

As for rainfall, the expected reductions in the same comparative periods are 2.4 and 6.8%. This decrease in precipitation should be added to the seasonality and variability expected to increase with variations ranging from -31.4% to + 22.3%, or inter annual variability from -22.3% to + 5.8%. There is no mention of meso geographic variability, which could aggravate these predictions.

This increase in temperature will generate a water deficit at the atmospheric level, which will increase the rate of evaporation (approximations of the IRTA place it at 25% higher than the current one, by the end of the 21st century; http://www.emporda.info/comarca/2012/03/23/sequera-podria-comprometre-recursos-hidrics.html; http://www.regio7.cat/cerdanya-alt-urgell/2016/09/02/sequera-reduce-caudal-del-segre/377116.html; http://www.irta.cat/ca-es/RIT/Noticies/pagines/Efectes-embassaments-Segre.aspx) and therefore under conditions of water availability, an increase in transpiration And in drought situations, an aggravation of water deficits in plant tissues.

In addition, global change promotes the combination of many of them in the same space and time, which can promote synergistic effects on vegetation in crops (Terradas 2010). It is also known that global climate change accompanied by an annual increase in the variability of the agricultural sector will increase the difficulties and risks in this sector (Reguant 2011).

Mediterranean Ecosystem was defined during 70s of last century for Mitrakos, Money, Montenegro, Fuentes (Kruger at al. 1983; Rundel et al. 1998; Roda et al. 1999), which characterized for some soil and environmental conditions, that promotes important adaptations of vegetation as sclerophyllous traits.

Under Mediterranean and in semiarid environmental conditions, more than 440 mm of annual rainfall are required for oaks forests to persist. Summer drought and winter cold are thus important abiotic factors limiting the distribution of oak species and fosters the development of shrub and secondary tree communities, mostly pine. In both cases, drought stress is involved.
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Olive groves have been, are and will be an important option in Mediterranean, semiarid and arid areas of the world in order to provide food, ecosystemic services, landscape, culture and population stabilization, similarly, this crop avoid fire risk, erosion….and desertization.

The objective of present work is to evaluate the sink capacity of olive groves under Mediterranean conditions in order to develop mitigation strategies against climate change.

Methodology

The methodology used to evaluate the olive groves as carbon sinks was different depending on the availability of the information, which in general is based in biomass, other biometric variables and age, obtained from destructive and/or nondestructive methods (Funes et al., 2015; Vayreda et al. 2016).

Results and conclusions

Results are showed in tables 1 and 2

Table 1. Equations used in aboveground (ABGB) and belowground (BGB) biomass estimation for Olive. TBA is trunk basal area (cm²). TBA data are based on non-destructive measures. Olive ABGB is estimated using a relationship between TBA-ABGB published in literatura (Villalobos et al. 2005). BGB was estimated from ABGB using a ratio (Root:shoot ratio) from literature (Nardino et al. 2013).

<table>
<thead>
<tr>
<th></th>
<th>Aboveground Biomass</th>
<th>Belowground Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBA=4.4888age^{1.5636} &amp; TBA=276.96ln(age)-479.96</td>
<td>From 1 to 8 years &amp; From 9 to 150 years</td>
<td>30% Aboveground Biomass</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Olive tree</th>
<th>0-4 years</th>
<th>5-11 years</th>
<th>12-50 years</th>
<th>&gt;50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon capture (Mg C/ha/any)</td>
<td>0.26</td>
<td>0.47</td>
<td>0.22</td>
<td>0.1</td>
</tr>
<tr>
<td>Plantation frame and tree density</td>
<td>100-200 trees/ha</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.- *Slope of equation biomass vs edge * Plantation frame and trees density.

Under these environmental and cultural conditions this crop is a real carbon sink by means of management in woody parts of plants and soil. So, in Catalonia (North East of Iberic Peninsula) carbon stock in an olive grove is close to 92 Mg or tons /ha in woody part of plants, besides, to this amount about 40 tons of the carbon in the soil can be added (Rodriguez Martin et al.2016;).
This values of carbon stock in wood are between the 107 Mg C/ha of an *Abies alba* forest and the 28 Mg C/ha of a *Pinus halepensis* community.

This important carbon stock can be developed according 4x1000 strategy and conservation agricultural practices....., in this way, olive groves are not the solution, but they are one of the real solutions against climate change in Mediterranean and semiarid conditions (Savé et al 2016).

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**References**


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Abstract

The potential and the benefits of the contribution of satellite-derived data for warning purposes in agriculture due to climate variability and change are presented and discussed. Earth observation from space has a unique capacity to provide global data sets continuously and consistently not only on this level, but also on the national and local levels and the use of alert and warning systems must be based on such data. Evaluation of the agricultural impacts represents an important contribution for the assessment of vulnerability of agricultural systems to climate variability and change. Some of the climatic and biophysical variables essential for understanding and monitoring the climate system and the impact on agriculture can be efficiently observed from space since this technology enables their systematic, global and homogeneous measurement. The analysis and the presentation of the data records which have been developed from operational satellite observations, presents the status of satellite climatic and biophysical data for warning purposes for agriculture, in Europe. Among European countries there is a great inhomogeneity concerning climatic and biophysical data received from satellite sensors or collected as satellite-derived ready products. Some of them are currently collecting satellite data for years and these data records could be useful for models for climate change impact studies.

Key words

Climate change, agriculture, satellite remote sensing

Introduction

Climate variability and change is a global issue, which must be addressed with global models and global data are needed as input to these models. Some of the climate and biophysical variables essential for understanding and monitoring the climate system and the impact on agriculture can be efficiently observed from space, since this technology enables their systematic, global and homogeneous measurement. Climate and agriculture research is generally based on data collected for other purposes, primarily for weather prediction. To make these data useful for climate impact and warning studies, it is usually necessary to analyse and process the basic observational raw data and integrate into models.
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The new generation of satellite sensors has brought an upgraded level of remote-sensed information to the user community thanks to a much better spatial, temporal, spectral and angular sampling of the radiative fields emerging from the surface of the Earth.

Development of satellite remote sensing allowed for completely new possibilities in weather observations. Data coverage, both spatial and temporal was largely increased. Sensors installed on meteorological satellites were designed for measurement and observation of typical meteorological variables, which are also base for climate monitoring. Additionally, satellite sensors make possible observations of land and sea surface and their features related to actual state of surface-vegetation, temperature, moisture, chlorophyll concentration, suspended matter, wind, etc. (Struzik et al., 2008).

Meteorological satellites are present in space since almost 50 years. Such a long period allows for climatological studies based on remotely sensed observations of the Earth and atmosphere. The longest series concern cloud observations but continuous improvement of instruments made possible also: air sounding, land surface properties observations, oceans and seas monitoring, snow and polar ice caps observations and many other application.

Monitoring of climate require observations which are related to processes which are driving forces for possible changes. Space observations provide valuable information in global, continental and regional scale which helps to better understand processes which are hardly detected by point ground measurements.

Materials and Methods

For analysis of long term processes related to climate, tools with high stability and low uncertainty are required. The question is whether instruments placed onboard of meteorological satellites are characterised by enough level of mentioned parameters.

Long term monitoring of vegetation status make possible to detect temporal changes of beginning and finish of vegetation season.

Most of the operational satellites were created as weather rather than climate platforms. As a result, long term absolute accuracy of satellite measurements was not a crucial issue. In the measurement of the climate variable it is vital for understanding climate processes and changes. However, it is not as necessary for determining long-term changes or trends as long as the data set has the required stability. And, when it comes to building satellite instruments, stability appears to be less difficult to achieve than accuracy. The difficulty arises because of the many known and unknown systematic uncertainties that are to be accounted for in the calibration of the
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instruments. Although excellent absolute accuracy is not critical for trend detection, it is crucial for understanding climate processes and changes.

To integrate space research on global or regional scale climate change, it is needed to develop data bases with climate and biophysical data records. During creation of satellite based Climate Data Records unique challenges appear:

-the need to manage extremely large volumes of data;
-restrictions of spatial sampling and resolution;
-accounting for orbit drift and sensor degradation over time;
-temporal sampling;
-difficulty of calibrating after launch (e.g., vicarious or onboard calibration);
-the need for significant computational resources for reprocessing.

A chronic difficulty in creating a continuous, consistent climate record from satellite observations alone is that satellites and instruments have a finite lifetime of a few years and have to be replaced, and their orbits are not stable. Most important is proper calibration of satellite sensors during their entire time. This can be done by pre-launch calibration, post-launch vicarious calibration and intercalibration.

Cloud cover is a major constraint on optical remote sensing, whether it is spaceborne, airborne or ground-based observation, particularly in cloudy regions.

In the frame of the EU COST Action 734 programme CLIVAGRI (Impacts of Climate Change and Variability on European Agriculture) (http://www.cost734.eu/), satellite data records, e.g. series of observations over time that measures variables believed to be associated with climate variation and change, were surveyed and collected among European countries, based on a specific questionnaire. The analysis of the data records which have been developed from operational satellite observations, presents the status of satellite climate and biophysical data for warning purposes for agriculture, in Europe (Toulios et al, 2008).

Results and Discussion

Among European countries there is a great inhomogeneity concerning climate and biophysical data received from satellite sensors or collected as satellite-derived ready products. Some of them are currently collecting satellite data for years and these data records could be useful for models for climate change impact studies. SEVIRI/METEOSAT and AVHRR/NOAA are the most popular satellite sensors which provide climate and biophysical variables, among the surveyed countries.
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These two satellite systems are widely used by the European Meteorological Services, most countries having their own satellite reception systems. MODIS and ASTER onboard TERRA or AQUA platforms are preferred by a lot of the European countries due to easy accessibility via internet and because their improved spatial, temporal and spectral characteristics are appropriate for many agricultural applications.

The main variables that are collected in operational or experimental way are land surface temperature and NDVI (Normalised Difference Vegetation Index). In a second series of the climate variables are cloud products, snow cover, radiation, land cover, precipitation and SAF products. Evapotranspiration and albedo follows, and the rest variables only in specific cases (Air-stability, Storm detection, Ozone content, Vegetation Condition Index (VCI), Temperature Condition Index (TCI), Soil moisture, Modified Soil Adjusted Vegetation Index (MSAVI), leaf area index (LAI), Degree days, sea ice and sea wind).

There are differences between countries regarding the use of climate and biophysical variables, explained by the fact that the high level products (like evaporation, soil moisture, storm detection, etc.) require quite complex algorithms or schemes. The SAF (Satellite Application Facility) products are not extensively used by many countries. It has also to be mentioned that in many countries the assimilation of satellite data into crop growth simulation models is still in an experimental stage.

NDVI is still considered one of the most successful of many attempts to simply and quickly identify vegetated areas and their "condition" and it remains the most well-known and used index to detect live green plant canopies in multispectral remote sensing data. In addition to the simplicity of the algorithm and its capacity to broadly distinguish vegetated areas from other surface types, the NDVI also has the advantage of compressing the size of the data to be manipulated by a factor 2 (or more), since it replaces the two spectral bands by a single new field. Nevertheless, it must be noticed that the NDVI has tended to be over-used in applications for which it was never designed. For example using the NDVI for quantitative assessments raises a number of issues that may seriously limit the actual usefulness of this index if they are not properly addressed. The NDVI should be used with great caution in any quantitative application that necessitates a given level of accuracy. All the perturbing factors (atmospheric soil effects, anisotropic effects and spectral effects) that could result in errors or uncertainties of that order of magnitude should be explicitly taken into account; this may require extensive processing based on ancillary data and other sources of information. More recent versions of NDVI datasets have attempted to account for these complicating factors through processing.

The satellite-derived surface temperature (for land and sea), is also a broad used climate variable among the surveyed countries. Surface temperature is used in various agro-meteorological applications like: surface heat energy balance study, characterization of local climate in relation with topography and land use; mapping of
low temperature for frost conditions or winter cold episodes; derivation of thermal sums (using surface temperature instead of air temperature) for monitoring crop growth and development conditions. Polar orbiting satellites in low orbit can provide much better spatial resolution and hence potentially more useful estimates of surface temperature than can other measurement methods.

Some variables like albedo, evapotranspiration, air-stability, storm detection, ozone content, soil moisture, sea wind and ice are used by a much reduced number of countries. This can be explain by the fact that the procedures used to retrieve such variables are still in experimental phase and do not satisfy the user requirements related with accuracy, spatial or temporal scales, etc. For example soil moisture is an important parameter for weather and climate prediction as well as for crop monitoring. Many efforts have been made for soil moisture estimation with space-borne sensors and in-situ measurements. These approaches measure soil moisture at different spatial scales and each of them have certain advantages and limitations. Microwave remote sensing measurements can provide physical retrieval of soil moisture in low vegetation areas, but have poor spatial resolution. Optical/IR measurements can be used to retrieve soil moisture at high spatial resolution statistically, but limited to clear days. In spite of these results, presently soil moisture retrieval with satellites is still not operationally available. The new generation of microwave remote sensing satellites will provide soil moisture products in the near future.

Satellite data offer an unprecedented potential for climate research provided that separate sensor/satellite data are integrated into high-quality, globally-integrated climate products. Also climate change influence on biosphere can be monitored with use of satellite data. Presence of meteorological and environmental satellites in space since 60-ties allows for real climatological studies. Main issues are accuracy and stability of satellite measurements. Actually, not all climate related variables can be traced with use of satellite sensors due to their not sufficient accuracy. Much improved post launch calibration of satellite instruments, and intercalibration of similar instruments flying on different satellites is highly required to achieve continuity of observations. This requires overlapping periods of consecutive satellite missions. Other problem concern data management (processing and reprocessing). Rapid development of Earth observations resulted with extremely huge volume of satellite data. Regarding future missions, new more accurate sensors are envisaged.

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