Effect of olive core and olive core ash on the growth of *Helianthus annuus* and soil quality

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Abstract

Field experiments were carried out using *Helianthus annuus* in an attempt to improve the quality of soil conditions by application of industrial waste. A range of quantities of olive core, olive core ash and a mixture of the two kinds of waste were applied. In all experimental fields the plants reached their maximum height on the 80th day of their growth. The application of olive core increased the plant height and decreased the soil pH, suggesting an increase in the nutrient element bioavailability. There was also evidence that olive core increased the soil microbe biomass. Furthermore, olive core woodash gave the dry biomass of *Helianthus annuus* a boost.

Keywords: Olive core, Growth, *Helianthus Annuus,* Soil Quality

1. Introduction

The interval of biological cycle of Helianthus depends on genotype and the climatic conditions prevailing during the growing season (Olivier and Annandate, 1998; Ferreira and Abreu, 2001). Compared to lower temperatures that elongate the biological cycle, at high temperatures plants use more water and sunshine producing greater biomass (Cirilo and Andrade, 1994, Andrade, 1995). Younger plants usually exhibit greater resistance at low temperatures rather than older ones. The photosynthetic capability of the plant reaches its maximum at 28 °C. The maximum production in seed is achieved at temperatures ranging between 24 and 26 °C during the day and 18 and 20 °C during the night.

Helianthus can grow in a variety of latitudes from Russia to Argentina and can be cultivated in a variety of soil types from sandy to clayey even in soils poor in nutrients. It can also grow in slightly acid to neutral soils. The maximum leaf surface is controlled by the density of the plants in the field. The period of life of the leaves is also an important parameter (Xanthopoulos, 1993). Leaf surface, being of the most important parameters for Helianthus that controls its productivity and reflects its capability in using the water and the nutrients (Unger, 1981; 1983), was one of the parameters used in the investigations carried out in this study.

The rate of increase of Helianthus root, being greater than that of the above soil plant part, is very characteristic. As the plant reaches a height of 40 cm its root has a length of 70 cm. At the first stage of the plant development a considerable number of secondary roots develop horizontally until they use all surface water. Then secondary roots tend to increase vertically downwards. The maximum root length can reach 150-270 cm.

Regarding the plant density population of the Helianthus crop, recent experiments showed that optimum production is accomplishable at 4500-5000 plants/ha for non-irrigation corpus and 5500- 6000 plants/ha for irrigation corpus. It is noted that the nutrient concentration levels in the irrigation waters as well as in the soils play an important role in the biomass production (Kalavrouziotis *et al.* 2002; 2006; 2007).

2. Materials and methods

An experiment was conducted in the region of Atalanti, Greece (38 39 24.44 N, 23 02 01.32 A.E.) at an altitude of 32 m using a completely randomized block design, with the application of the following treatments: (i) Control, (ii) olive core waste, (iii) Olive core ash, and (iv) Olive core ash + olive core waste. *Helianthus annuus L* was used as the experimental crop. Sowing date was April 25, 2011. The dimensions of the experimental plots were2x3 m, that is 6m² plot surface. Soil was prepared through mixing and homogenizing the waste at 20 cm depth. On the basis of the physical characteristics, the experimental soil is described (according to Bouyoucos, 1962 classification system) as sandy silt soil (49.3% sandy, 28.7% clay, 22% loam) with a calcium rich substrate, pH of 8.1 and organic content of 1.45% (Mitsios, 1999).

The olive core was mixed with soil in various proportions to make the following four treatments: the witness that was 100% soil (M-treatment); the E-treatment included olive core 7%; the T-treatment comprised olive core ash 1.5%; and the ET-treatment was a mixture of olive core 8% and

olive core ash 1.5%. The experimental layout in regards with the type of waste used in each plot is described in Figure 1. Plant height, dry weight biomass and the surface of the leaf of Helianthus were examined, so as to ascertain the effects of olive core waste on plant growth.

Olive Core: Olive core is a solid waste derived from olive oil industries after the separation the oil. The water content of the soil waste varies between 38% and 65% depending on the method used, the type of olives and the time of the activity. The remaining of the solid waste consists of 45% wooden material, oil 3- 4%, as well as organic and inorganic constituents being responsible for the smell. Greece is the third olive oil production country in the world following Spain and Italy with an annual production of olive core wood varying between 700,000 and 800,000 tones. Considering an annual production of olive core wood of 5000,000 tones the annual production of ash in Greece is 42,000 tones.
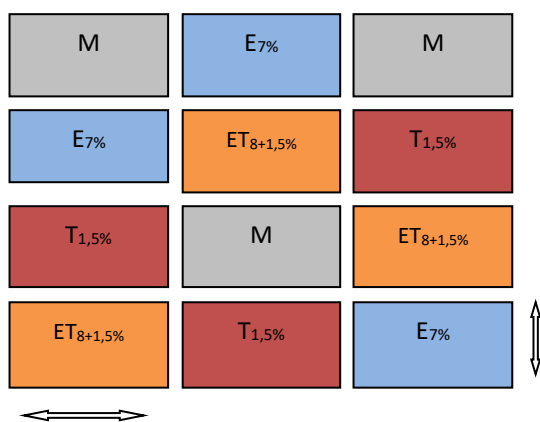
M	E$_{7\%}$	M
E$_{7\%}$	ET$_{8+1,5\%}$	T$_{1,5\%}$
T$_{1,5\%}$	M	ET$_{8+1,5\%}$
ET$_{8+1,5\%}$	T$_{1,5\%}$	E$_{7\%}$

Figure 1. Description of the experimental plot arrangements (Where: M: Reference planting, E 7%: Olive core 7% of the soil in the upper 20cm, T 1, 5 % : Olive core ash 1, 5 % in the upper 20 cm of the soil, ET 8% + 1,5% : Olive core 8% with olive core ash 1. 5%).

3.   Results and Discussion

3.1 Determination of the Physicochemical characteristics of the waste

The physicochemical characteristics of the waste and methods of analysis used are shown in Table 1.

It can be seen that pH, Electrical conductivity, C/N ratio, total carbon and especially sodium content of the olive core ash, differ significantly from the corresponding values of the wet olive core. Obviously the ashing of the core at 250 °C resulted in the concentration of the salts, and of course in the decrease of carbon and organic matter.

3.2 Leaf area determination

Leaf surface determination measurements were carried out on the 5th- 6th and 16th – 17th leaves. For the leaf surface measurement leaf length and width were measured using the software Auto CAD 2010.

A copy of the leaf on a paper was made followed by scanning (AREA AUTOCAD). Five plants from each experimental field were sampled and their biomass was

determined after drying at 100 °C. The surface measurement of the 16th leaf, showed a decrease in its surface under the olive core, and olive core ash, application. In both cases the decrease level of leaf surface was similar compared to the control, in agreement with other researchers who also found that the application of olive core reduces the plant height and the leaf surface (Alt and Kromhout, 1997; Bouranis *et al.*, 1995). These researchers refer to compost olive core though. Fig. 2 shows the variability of leaf area in relation to time variability during the plant growth at various applications of waste in the present experiment.

Table 1. Chemical and physical characteristics of the wet olive core and olive core ash used in the experiment

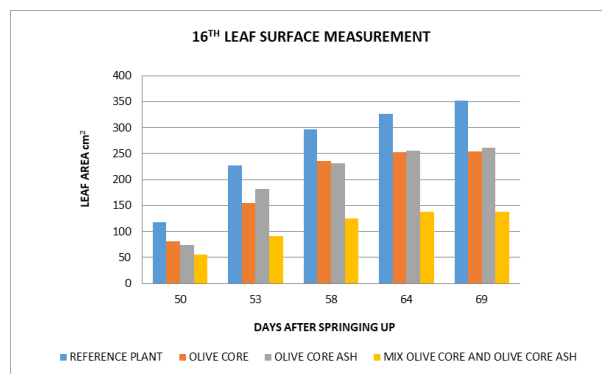| Parameters	Wet olive core	Olive core ash	Method
pH	7.1	13.3	1:2 H$_2$O
Organic matter (%)	96.7	9.2	INCINERATION
Elec. Conductivity (mS/cm)	9.0	<120	1:10 H$_2$O
Nitrate-N-(NO$_3$-N) mg/kg	3.5	108	IN KCL
Total N (%)	0.23	0.23	CALCULATION
C/N ratio	209	20	CALCULATION
Carbon (C) %	48	152	INCINERATION
Sodium (Na)mg/kg	188	2700	CALCULATION

Figure 2. Variability of leaf area in relation to time variability during the plant growth at various applications of waste

3.3 Height measurements

During the plant growth period the following measurements were made:

- Measurements of height every 10 days between soil surface and plant top. At flowering the height was measured every two days between soil surface and top of the flowers.

The results of plant height measurements under the effect of experimental treatments are shown in Fig. 3.

At the 35th day of growth there were no statistically significant differences between the height values among the various experimental treatments. Similarly, no statistically significant height differences were observed at the 53th day of growth in any of the experimental

treatments. The plants under the effect of all treatments reached their highest height on the 80th day of growth, while after this day their height remained constant. After the 80th day and onward there was a positive influence of the olive core on the increase of plant height differing statistically significantly from the reference plants (control).
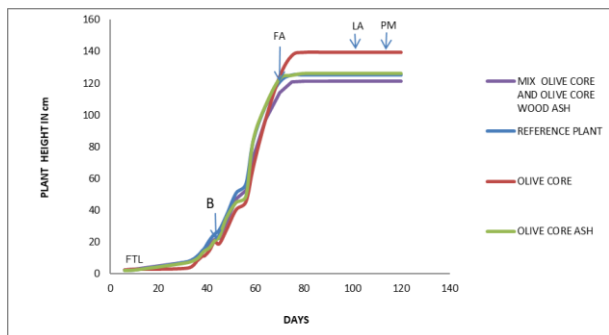

Figure 3. Increase of plant height during the growth period from first true leaf to physiologic maturity (FTL=First true leaves, BE=Bud Emergence, BE=Bud Emergence, LA=Last anthesis, LA=Last anthesis, PM=Physioloic maturity)

Consequently, it can be concluded that the olive core constituents have a positive influence on the growth of the plants. Foliar surface and plant height were reduced at higher concentrations of total olive core. This agrees with the observations of other researchers (Alt and Kromhout, 1997; Bouranis *et al.,* 1995). Similar results were observed on tomato plants. This most probably is due to the improvement of the soil quality achieved by the olive core on soil structure and fertility. This may be the result of favorable effect of olive core on certain soil parameters such as increase of the availability of nutrient element, and improvement of the substrate favoring the microbial activity that leads to increase of microbial biomass.
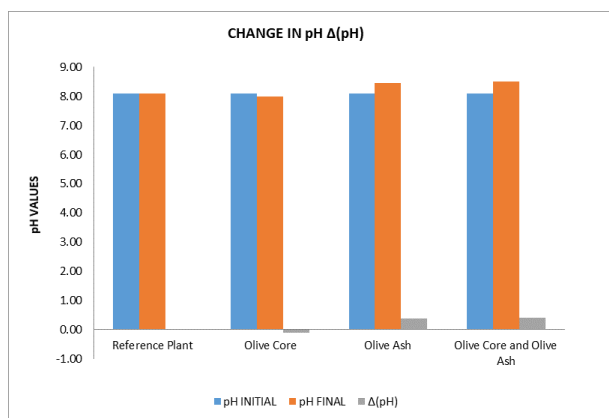

Figure 4. Effect of the applied treatments on soil pH

Another important positive influence of the application of olive core on soil was the decline in the initial pH value, i.e. 7.99 versus 8.10 (Fig.4).

It is therefore suggested that pH decrease leads to the increase of the elemental bioavailability, a factor playing an important role in the development of the plants.

By contrast, the application of the olive core ash led to an increase of the soil pH value from 8.10 to 8.47 (Fig. 4). The surface measurement of the 5th leaf showed a decrease under the olive core, relative to the control. A decrease in the leaf surface but smaller than that described above was also observed for the plants under the olive core ash application (Fig. 2). The height, being a characteristic parameter, was strongly influenced by the climatic and soil conditions and played an important role in seed and oil production (Frangella *et al.,* 2002). The surface measurement of the 16th leaf, showed a similar decrease in its surface under the olive core, and olive core ash, application. In both cases the decrease compared to the leaf surface of the reference (control) treatment (with no applications) was similar.

Ferreira and Abreu (2001), studied the dry biomass of Helianthus in relation to its biological cycle and concluded that it reaches its maximum weight at the stage of blooming. Afterwards, the corpus and leaf biomass decreases. In the present experiment, the measurement of the dry weight was carried out 94 days after the seeding. Also, the seed moisture was measured and was found to be 17%.
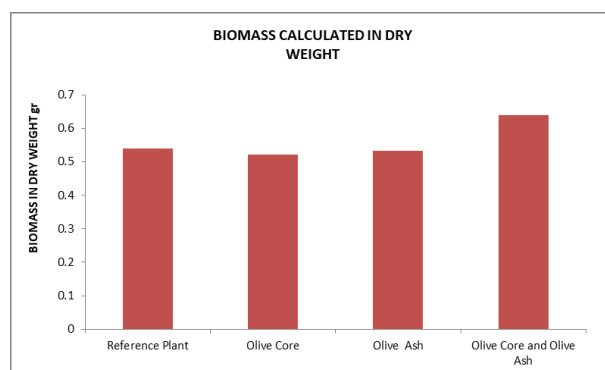

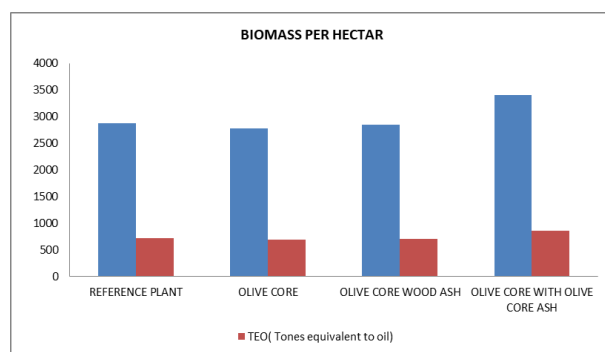**Figure 5.** Effect of the applied treatments on dry weight of biomass

Figure 6. Dry biomass per ha in relation to TEO (tones equivalent to oil, 1 tone biomass equals to 0.4 tone oil)

The analysis of the above diagrams (Figs 4, 5 and 6) showed that the cultivation of Helianthus in the present experiment produced 3- 3.5 tons of dry biomass/ha.

The application of the olive core ash in the present experiment showed an increase in the dry biomass production.

4. Conclusions

1. Cultivation experiments of *Helianthus annuus* showed that industrial waste can be applied on the field during crop growth improving the quality of soil conditions. Because of the high proportion of C/N it could be used as soil enhancer without further process.

2. Olive core and olive core ash treatments showed that the plants in plots reached their maximum height on the 80th day of their growth.

3. The application of olive core resulted in an increase of the maximum height of the plant relative to the reference plant.

4. Availability of nutrient elements in the olive core waste and / or its action as microorganism substrate may justify its positive role in the growth of *Helianthus annuus*. The presence of olive core waste in the soil may increase the microbe biomass, increasing the fertility of the soil.

5. The application of olive core decreased soil pH by 0.11; in turn it is expected to increase the bioavailability of nutrient elements.

6. In contrast, olive core wood ash in the soil increased pH by 0.37.

7. Dry biomass measurements showed an increase in the dry biomass of *Helianthus annuus* after the application of olive core ash in the soil.

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