FEASIBILITY OF WASTEWATER IRRIGATION FOR SMALL-SCALE BIODIESEL PRODUCTION

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Abstract

In a growing concern of water and energy availability decrease, the sustainable growth of *Jatropha curcas L.*, without interfering food security and avoiding extensive monocultures, may be a feasible and complementary alternative within the local non-conventional energies field. Bearing in mind the increasing environmental awareness concerning bio-diesel production when non-sustainably managed, this project emphasizes the idea of using wastewater agriculture in a reduced area of study always implemented as a complementary local energy option. The main goal of the project focuses on studying the feasibility of wastewater reuse for *Jatropha curcas L.* irrigation, analysing its possible groundwater pollution implications. The statistical analysis shows that no significant differences were found in the studied growing parameters when irrigating with groundwater or wastewater respectively. Aquifer water quality was neither affected when wastewater irrigation took place.

Keywords: irrigation, wastewater reuse, groundwater quality, bio-diesel, *Jatropha curcas L.*

1. Introduction

The cultivation of *Jatropha curcas L.*, non interfering food security, might be a feasible option within the renewable energies field. If cultivated in a sustainable way, avoiding the big-dimension monoculture and so the environmentally related issues derived from it, it might emerge as an additional option within the non-conventional energies field, not only due to its oil (30-40% possibly converted into bio-diesel) but to its secondary products: glycerin and the resulting cake from oil extraction, possibly used as fertilizer (Achten et al., 2007).

Taking into account that irrigated agriculture is the main water consumer (FAO, 2007), reuse of wastewater effluents derived from wastewater treatment plants (WWTP) is considered as a technical solution to cope with growing water

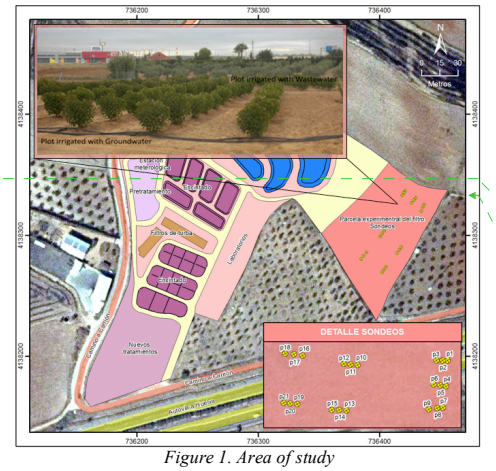

Figure 1. Area of study

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demand (Kiziloglu, 2007), always encouraging water savings in a first place. As Scott (2004) states, agriculture wastewater might help in alleviating the limited water resources availability.

The actual project, located in the experimental plant "Carrión de los Céspedes" *(figure 1),* involves wastewater reuse in agriculture for *Jatropha curcas L.* irrigation, known as a bioenergetic crop.

2. Objectives

The principal purpose of this study focuses on analysing the outstanding differences derived from irrigating *Jatropha curcas L.* with either groundwater or treated wastewater effluents.

The specific objectives are two-fold. First, to analyse the major differences on *Jatropha* development so linked to biofuel production and second, groundwater quality implications derived from irrigating with wastewater sources.

3. Methodology

Experimental design and data collection

The experiment has been conducted within two plots equally designed, presenting an area of about 300m^2. Focusing on achieving the most accurate results, the only difference lies on the quality of water applied for irrigation. To avoid notable interferences, both plots were located against groundwater flow.

For *Jatropha curcas L.,* a planting pattern of 3.5x2m, with a population density of 1430 units/hectare was designed for each plot. When deciding the unit samples, those located at the plot borders were rejected so as to avoid any kind of non-desirable variables. Due to the reduced number of units, non-destructive methods were applied. For the consecutive experiment measures, 12 units were chosen per plot, choosing those ones presenting same features. The driven measures have involved three variables: Height, Crown diameter and Thickness, always measured at a fix distance from the plant base. Further studies will also analyse differences within photosynthesis efficiency.

In order to estimate the irrigation water requirement, the CROPWAT model (FAO, 2007), based on the Penman-Monteith equation and adapted by FAO, was implemented. This model requires climatic variables (precipitation, temperature (minimum, maximum and average), wind and humidity)[1], soil variables[2], and crop coefficient[3]. The water needed to satisfy the crop potential evapotranspiration (PET) was applied within a drip irrigation system consisting of 2 independent lines driving groundwater or wastewater respectively. Each line was subdivided into subdrip lines, supplying water through two droppers per specimen, with an individual flow of 12 L/min, lower than the soil infiltration capacity.

Secondly, to analyze the possible effects of wastewater irrigation onto aquifer water quality, 3 piozemeter networks were installed. One unit was located within the "groundwater"[4] plot whereas the two others were placed within the one irrigated with wastewater. Each network is composed of 3

[1] Data from the Spanish Meteorological Agency stations (AEMET): Carrión de los Céspedes, Aznalcazar amd San Lúcar la Mayor

[2] Soil texture, infiltration capacity and soils horizons have been setimated

[3] A crop coefficient between 0,51-0,70, for a vegetative period of 210 days (Abou Kheira and Atta 2009; Achten, Maes et al. 2010) has been implemented

[4] The groundwater used for irrigation comes from a different aquifer unit to the one which is below the experimental plot

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piezometers at different depths (2, 4 and 10 meters). Samples are taken regularly, both for irrigation water (ground and wastewater) and piezometers. These samples are analysed, obtaining qualitative variables: pH, COD, TOC, alkalinity, dissolved anions and cations, and microbiological parameters.

To avoid problems in the starting season, the first three months both plots were irrigating with the same water (april to june with groundwater). The experiments started in June.

Stadistical analysis

So as to determine if significant differences were found within the studied variables, a statistical analysis has been conducted. This analysis is made up of a normality test, an analysis of means distribution (t-test), a Snedecor's F distribution (F-distribution) and a correlation analysis using Pearson's coefficient.

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4. Results

Vegetative growth

Figure 2 shows the evolution of the main growth variables. All showed continuous growth. For the development period, both the Crown diameter and the Thickness are adjusted to a linear equation whereas the Height is adjusted to a quadratic equation. The correlation coefficient is greater than 95% in case of Height and Thickness. In case of Crown Diameter is greater than the 80%. It is noted that the variables have similar behaviour in both plots (red and blue lines).

The statistical analysis has verified the normal distribution. In case of T-distribution (Student's t-distribution), for a 95% confidence interval, the null hypothesis (equal means) can not be rejected. In case of F-distribution (Snedecor's F distribution), for a 95% confidence interval, the null hypothesis (equal variances) can not be either rejected. Based on that, it can be concluded that no significant differences related to growth patterns were observed.

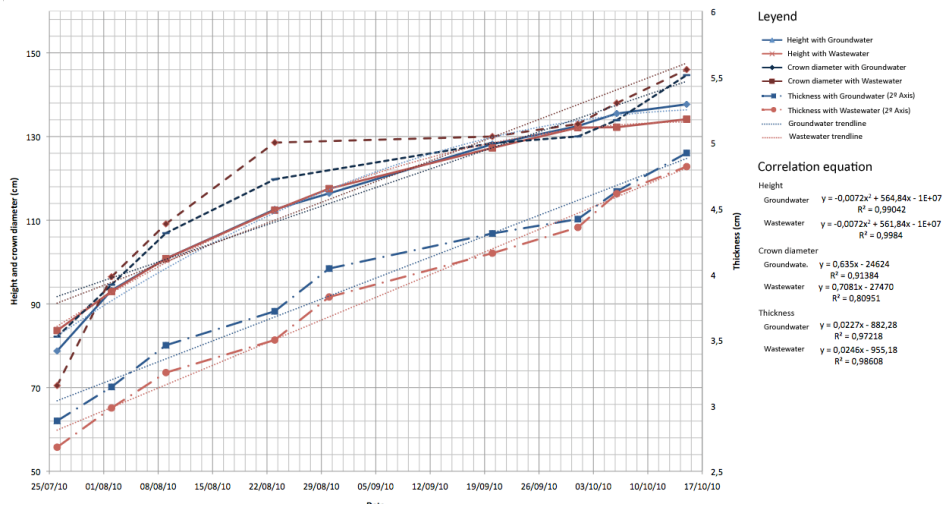

Figure 2. Main variables evolution (average). Height and crown diameter are represented in the main axis; Thickness is represented in secondary axis. The point line represents the trend line for each parameter and plot.

Groundwater quality

No changes were found in aquifer quality after irrigation campaigns. All the parameters present the same evolution in both plots. In case of nitrogen, and due to the irrigation water was better than the aquifer quality, the parameter presents an small reduction (10%).

5. Conclusions

As a conclusion, it can be said that no notable differences were found within the two studied plots. Irrigating *Jatropha curcas L.* with wastewater does not negatively affect its vegetative growth. On the other hand, groundwater pollution was not detected when irrigating the plant with wastewater. Wastewater irrigation, aimed in this case to small-scale bio-diesel production, may help to alleviate local water resources availability pressure.

6. References

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