# Water footprint and life cycle assessment of *Populus spp*. bioenergy system: a case study in Southern Europe


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## 1 Introduction

Short rotation energy crops have been promoted because they provide biomass in short periods of time but the impacts of water consumption on existing water resources have not been analyzed in depth. Previous studies has conducted of *Populus spp*. bioenery systems[1,2] focus on environmental impacts and it has detected that water consumption will be crucial for Southern Europe. This study evaluates the **water footprint (WF) and the life cycle assessment (LCA) of a *Populus spp*. crop in Spain through its first cycle for two planting densities in order to evaluate if water consumption would be different for the same energy production.**


- ✓Low input agrochemical
- ✓Cycle: two years
- ✓Low Density: 6,666 pl ha$^{-1}$
- ✓High Density: 20,000 pl ha$^{-1}$

*Crop of Populus spp. bioenergy system studied*

## 3 Methodology

For the water consumption has been used the methodology of water footprint (WF)[3,4] and for the energy and environmental assessment it has been used the life cycle analysis methodology. Grey WF has rejected due to low input of agrochemical requirements.

### 3.1 Life cycle assessment- Functional Unit

To obtain 1 ha of *Populus spp*. destined to produce biomass throughout the first cycle of *Populus spp*. bioenergy system.

### 3.3 Life cycle Inventory and life cycle impact assessment

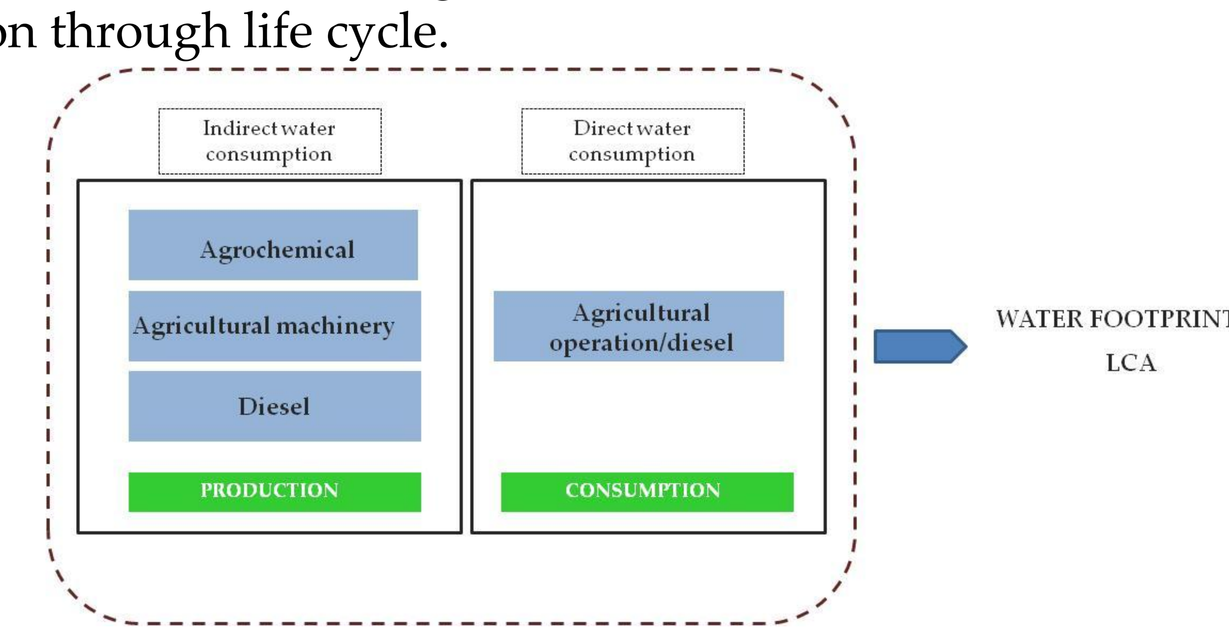
Data has been collected throughout the first cycle of the crop and ecoinvent 2.0 (2007) databases. The LCIA methodology used has been "Cumulative Energy Demand v 1.4" and "CML baseline 2001".

| | Low Density | | High Density | |
|---|---|---|---|---|
| | Indirect water | Direct water | Indirect water | Direct water |
| Agrochemical production ($m^3$ ha$^{-1}$ yr$^{-1}$) | 310 | | 507 | |
| Agricultural machinery ($m^3$ ha$^{-1}$ yr$^{-1}$) | 24 | | 269 | |
| Diesel ($m^3$ ha$^{-1}$ yr$^{-1}$) | 12 | | 21 | |
| Irrigation ($m^3$ ha$^{-1}$ yr$^{-1}$) | - | 1,808 | - | 3,288 |

*Water life cycle inventory of Populus spp. bioenergy system for LD and HD*

## 2 Systems description

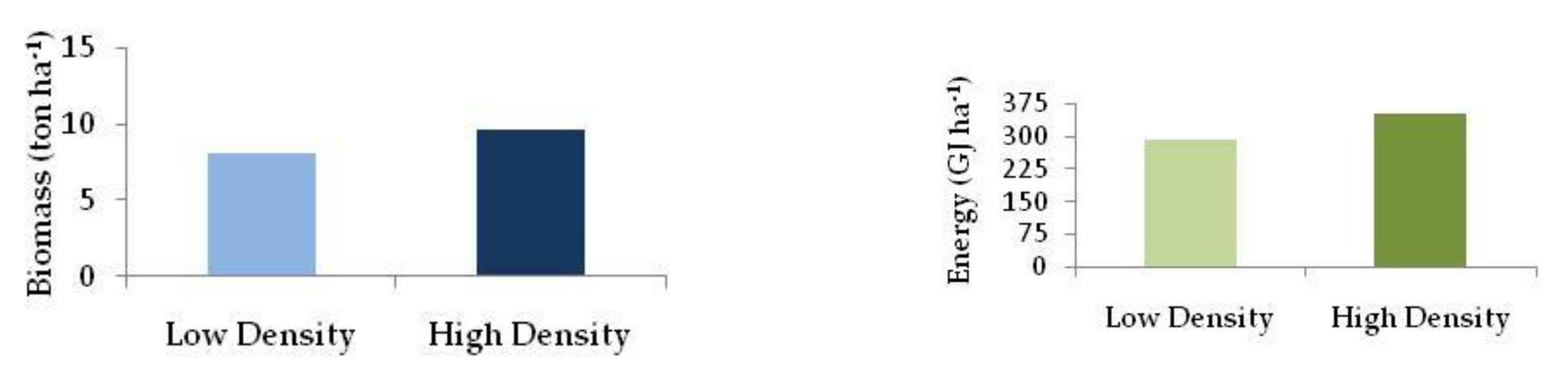
The system under study includes all stages of agricultural production for the first cycle of the crop: work in the plantation, production of agrochemicals, tractor and agricultural utensils manufacture as water consumption through life cycle.




*System boundary of Populus spp. first cycle*

## 4 Results and discussion

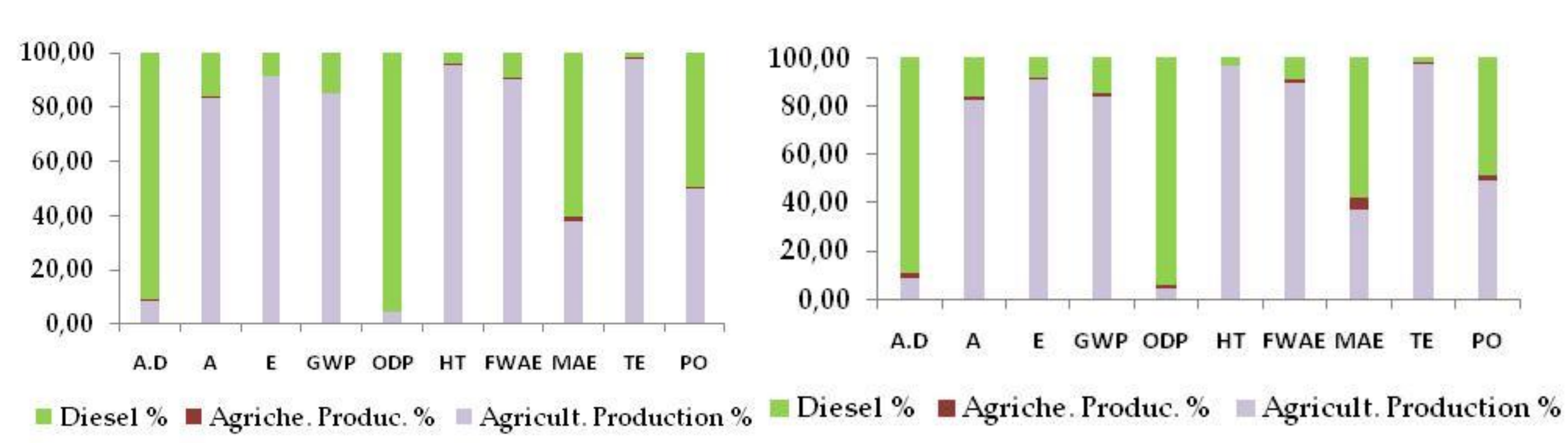
Biomass and energy per ha obtained; and blue WF and green WF for both planting densities per ton and per GJ obtained and the biomass and energy obtained.




| | LD ($m^3$ ton$^{-1}$) | HD ($m^3$ ton$^{-1}$) |
|---|---|---|
| Blue WF | 266 | 396 |
| Green WF | 754 | 628 |
| Total WF | 1020 | 1023 |

| | LD ($m^3$GJ$^{-1}$) | HD ($m^3$ GJ$^{-1}$) |
|---|---|---|
| Blue WF | 7 | 11 |
| Green WF | 21 | 17 |
| Total WF | 28 | 28 |

Figures present the relative contributions of life cycle stages of low density and high density for the first cycle of *Populus spp.*, respectively.




*Relative contributions of life cycle stages of LD* *Relative contributions of life cycle stages of HD*

## 5 Conclusions

The total WF is high for bioenergy production of Populus spp. in Southern Europe and per ton produced and for GJ obtained, values are similar for both densities consider (28$m^3$ · GJ$^{-1}$). However for high density a higher amount of water is required from the ground or surface area and this type of planting density could increase water demand in the area(3,288 $m^3$ ·ha$^{-1}$· yr$^{-1}$). Bioenergetic system of *Populus spp*. in southern Europe should be restricted to areas where water availability is abundant and low density design is preferred to higher densities. Results from LCA indicated that for both densities the highest environmental impacts are due to agricultural machinery production. Low input design in agrochemical consumption implies a reduction of environmental impacts.

**References**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