Sustainable woody biomass production systems: a novel solution for energy, agriculture and the environment in Portugal

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Introduction

Bioenergy is a major issue within the agriculture and energy sectors and the society in general. The environmental and social concerns raised by first generation biofuel crops increased the interest on woody biomass. Biomass production for direct conversion to heat and/or electricity is common in northern European countries, the USA, and, more recently, southern Europe, mainly based on short rotation woody crops (SRWC). These crops are renewable sources of energy, CO2 neutral, able to preserve biodiversity and water, and to contribute to socio-economic development.

In Portugal, there is an increasing demand of renewable and sustainable sources of energy, particularly of low cost energy. Portugal also presents conditions to expand biomass production and use for energy, namely through SRWC. These conditions include a large growing season for the crops and an increasing availability of soils where these crops can be established. In spite of their strategic importance for the country and the environmental and socio-economic benefits to expect from these crops, there is a gap of knowledge and experience in this field in Portugal

Goals

In 2008 we launched a research project with the purpose of developing technology for the sustainable production and use of woody biomass for energy with environmental and socio-economic benefits in terms of carbon regulation, conservation of water, soils, and biodiversity, and creation of wealth at local and regional levels. We also aimed to evaluate the potential of the Trás-os-Montes region for biomass production for energy as well as the potential for carbon sequestration by forest systems.

Area of study

The study is centered in the Trás-os-Montes region, Portugal. The experimental plots are located in Bragança.

Components of the project

The project comprises the six tasks described in the following diagram:

Objectives

- To establish experimental SRWC for energy,
- To measure, monitor and model biomass production and flows of carbon, water, and nutrients in SRWC,
- To evaluate and model biomass production of other forest systems,
- To evaluate and model energy potential of woody biomass at a regional scale,
- To evaluate potential environmental effects of SRWC,
- To quantify energetically biomass from tree species in SRWC and conventional forestry systems,
- To evaluate the role of SRWC and conventional forestry systems on carbon sequestration,
- To analyse the sustainability of biomass production systems for energy,
- To establish SRWC demonstration areas.

Task 1

Biomass production systems

Consists in the installation and development of SRWC. Includes all the agronomical procedures to grow and monitoring the crop (site preparation and management, plantation, crop management, crop protection, fertilization, irrigation, and harvest). Includes also biomass growth and yield estimation, monitoring, and modeling. The SRWC were installed in a 4 ha area based on willow (Salix spp.), poplar (Populus spp.) and ash (Fraxinus angustifolia). Densities range from 15000 to 20000 cuttings per ha for willow and 10000-15000 cuttings per ha for poplar and ash.

This task will provide fundamental data on where and how to grow short rotation crops for energy efficiently in this region.

Task 2

Environmental effects of SRWC

In this task we will identify and solve eventual direct environmental impacts associated with the implementation and management of SRWC, namely decrease in water yield at small or large watershed scale, decrease in biodiversity and non point source pollution.

Emphasis will be on the impact of fast growing crops on water resources at the local and watershed scales. Biodiversity will be considered in terms of plant, animal (arthropods) and macrofungi species.

Task 3

Carbon cycle

This task aims to describe the carbon cycle at the short rotation system scale, to quantify the sequestration of carbon dioxide by SRWC, plantations and natural forests, and to evaluate the role of SRWC in the reduction of greenhouse gases at broader scales.

At the crop level we will quantify carbon fixed in plants and soil. We also quantify carbon flows among plants, atmosphere and soil. All stocks and flows will be used in modelling of carbon cycling in these short rotation crops.

At the regional level carbon will be estimated in association with the "regional woody biomass and energy production potential" task (see bellow). Regional biomass-carbon models will be used regionally applied to data on forest distribution to produce estimates of carbon fixed both spatially and temporarily in the region

Task 4

Energy content of woody fuels

This task involves the quantification of energy contents of several woody products from different forest systems. It will make possible to estimate the energy content in individual trees, parts of the tree considered as forest residues, cohorts, and forest stands.

Additionally, with data from the "Regional woody biomass and energy production potential" task bellow, it will make possible to estimate the actual and potential for heating and electricity from woody biomass in current and future forests in the region. These results are essential to define and evaluate strategies and policies for bioenergy and energy in general at local, regional and national level. It is particularly important since currently there is no data concerning these aspects in Portugal.

Task 5

Regional woody biomass and energy production potential

This task will produce data on biomass available for energy in the Trás-os-Montes region in terms of volume and energy content. It will also produce data on energy potential supply in time and in space in the region. None of these data are available in Portugal and are essential to support decisions on energy production and use at any scale as well as to increase efficiency of energy use and to support the development of alternative renewable energy sources in Portugal.

in addition, it will make possible to analyse distribution of biomass and energy in the region and to optimize the location of biomass plants or to support regional allocation of forest resources.

Task 6

Life cycle and sustainability analysis

This task will provide answers to essential questions such as Is biomass production in SRWC sustainable? or Is it worth energetically, economically, environmentally or all, simultaneously, to produce biomass for energy from conventional forestry or from SRWC? If yes, how can we improve the efficiency of the systems in terms of energy, economical parameters, biodiversity, carbon or other? If not, what can we do to make these systems balanced in terms of energy, carbon, economics, or all? Are there particular scales of sustainability for biomass production for energy?"

The modelling and simulations to be conducted in this task will provide essential data to access sustainability of biomass production systems for energy and to support decisions on energy, environmental, and natural resources policies.

Installation of the experimental SRWC plots in Bragança: a) The area of study before the installation of the crops; b) planting according to the double row system; c) manual planting of cuttings; d) cuttings of Salix; e) cuttings of Populus; f) fertilization with phosphorus; g) soil and arthropods samples collection; h) Populus cutting after plantation; i) Populus cutting a month after plantation; j) Populus plot 5 moths after plantation; l) Salix plot 5 moths after plantation

This research is supported by a grant from "Fundação para a Ciência e Tecnologia", Portuguese government (PTDC/AGR-CFL/64500/2006)

The **Centro Hospitalar do Nordeste** collaborates on this research project