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# Giant reed as energy crop for Southern Italy: An economic feasibility study

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ABSTRACT

Among renewable sources giant reed has attracted a growing interest as energy crop especially in Southern Europe, thanks to its low agronomic input requirements. This paper aimed at evaluating the economic feasibility of introduction of giant reed plantation as energy crop in the Southern Italy. In particular, an economic and financial analysis was performed by comparing giant reed (both for woodchip and chopped forage production) with traditional crops (pluriannual and annual) that are currently cultivated in the same area, such as wine grape, melon and tomato. Results showed the highest profitability of giant reed respect to other crops with current market prices. In particular, giant reed destined to woodchip production denoted the highest annual gross margin with a value of 647.10 € $ha^{-1}$, followed by giant reed for silage production (617.04 € $ha^{-1}$), wine grape (477.52 € $ha^{-1}$), melon (310.00 € $ha^{-1}$) and tomato (280.00 € $ha^{-1}$).

However, it should be considered that, as the cultivation of energy crops subtracts inevitably surface to the agricultural land, it would be desirable that the giant reed does not conflict with agri-food production, but valorizes marginal and/or unproductive areas.



**Contents**



## 1. Introduction

The issues related to the air pollution, the increasing energy demand characterized by a massive use of limited fossil fuels and the volatility of oil prices are, in short, some of the main factors that have determined the need to change the global energy mix [1].

Increased energy demands, EU intentions for energy independence, together with decreasing fossil fuel reserves, have initiated the interest for new technology development, such as renewable energies [2], which help to mitigate climate change, reduce dependence on fossil fuels [3] and diversify core business production [4,5].

In recent years, in fact, EU addressed increasing attention to the promotion and development of renewable sources that play an important role in the energy policy, both to reduce the energetic dependence from non-EU countries and to respect the Kyoto protocol [6].

Nowadays European policy in support of renewable sources is regulated by Directive 2009/28/EC (better known as the "20-20-20" targets) that set as objective for EU the achievement of a share of 20% from renewable sources in 2020 in the consumed energy mix [7].

Among renewable sources, biomass crops have attracted a growing interest for European energy production as early as 1970,

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because they are able to fulfill a significant portion of the EU's own energy needs, while reducing carbon dioxide ($CO_2$) [8–11].

The use of biomass crops for energy purposes (energy crops) has also affected the agricultural sector [12], where today it has spread the concept of "energy farm", i.e. a farm that integrates its agricultural production with revenues of energy deriving from renewable sources [13].

Therefore, dedicated biomass crops such as corn, wheat, triticale, sugar beet and recently also giant reed, have been largely cultivated for energy purposes [14–17].

Giant reed (*Arundo donax L.*) is a fast-growing polyannual perennial turf grass species native to East Asia growing spontaneously all over the world as an invasive plant reaching more than 8 m in height. It is a sterile plant which reproduces itself only agamically, through rhizomes and cane fragments which are transported by water or through human action [18,19].

Giant reed for its good combustion quality has been designated as one of the most promising energy crops in southern Mediterranean Europe [20–23], where the climate is characterized by hot summers and mild winters with minimal temperature variations.

In this production area, in fact, giant reed is highly productive in terms of dry matter per hectare, with a yield between 26 and 40 Mg $ha^{-1}$ D.M. $year^{-1}$ (50% w.c.) obtained in 20-year production cycle [24,25]. This is due to the fact that with respect to other energy crops, this species has low or nonexistent agronomic input requirements such as fertilizers, herbicides, pesticides [26], and it has a great potential to provide high N uptake, which would be a useful feature in environments under the European Nitrates Directive [27]. In addition, resilience of giant reed to environmental stress allows it to thrive on marginal, hilly and/or non-irrigated soils, typical of many Mediterranean areas [28–32].

Thus, since economic profitability is the most important factor for the adoption of a biomass crop for a farmer [33–38], this paper aimed at evaluating the economic feasibility of a giant reed plantation, comparing it with a traditional crop that has always played an important socio-economic role in the Southern Italy, such as wine grape [39,40]. In particular, an economic-financial analysis was performed in a case study located in the Sicilian coastal area, where it has been assumed a conversion from vineyard to giant reed plantation. Besides, in order to provide a more exhaustive and correct economic judgment, giant reed has been compared with melon and tomato, two traditional annual crops that are currently cultivated in the same area.

## 2. Materials and methods

In order to evaluate the economic feasibility of the introduction of giant reed as an energy crop, as well as in previous studies regarding other biomass crops [41–44], a comparison with traditional crops of southern Italy was performed. Specifically, an economic-financial analysis was carried out in a grape wine farm located in the coastal area of western Sicily, where it was hypothesized a replacement of a vineyard with a biomass giant reed plantation. The choice to compare these crops was due to the fact that they are the same production cycle (20 years) [45], facilitating the farmer in his decision-making.

Subsequently, in order to provide a more exhaustive and correct economic judgment, pluriannual crops were compared with two traditional annual crops that are currently cultivated in the same area: melon and tomato. Besides, these annual crops was chosen also because they are not eligible to the Single Payment Scheme (SPS) such as wine grape.

The research was carried out in 2014 in a grape wine farm of 15 ha.

Technical-economic data of vineyard, were collected by means of direct interviews to farmer of case study as well as in other studies [46,47]. In particular, the questionnaire included several questions and was divided into two main parts. The first gathered structural data (farm size, farm investments), while second focused on the production process (farming operations, inputs required for crop growing, workload) and farmer's revenues (yield, sales price).

Giant reed data were obtained through biomass market analysis and the existing literature [48,49], while for tomato and melon were provided by farmers of the object study area.

For each crop the economic analysis referred to the current prices of the last crop year (2013/2014) and it was considered that transport and farming operations (soil tillage, fertilization, pesticide treatments) were carried out exclusively through rental. As regards annual crops (melon and tomato), the human labor for manual harvest was considered, while for pluriannual crops (wine grape and giant reed) this farming operation is carried out through rental. Moreover, for the vineyard the human inputs required for pruning and others manual operations were included.

The wine grape cultivar was *Grillo* (Sicilian autochthonous variety) and the planting density was equal to 4000 plants $ha^{-1}$ ($2.50 \times 1.00$ m). During the maturity phase (from 3rd to 17th year) the average yield was 12.5 Mg $ha^{-1}$ $year^{-1}$, while in increasing production phase (2nd year) and in decreasing one (from 18th to 20th year) the yield was estimated 70% and 80% of maturity phase, respectively. The wine-grape market price was equal to 400 € $Mg^{-1}$.

With regard to giant reed the planting density was equal to 9800 plants $ha^{-1}$ ($1.40 \times 0.70$ m) with an average annual yield during maturity phase (from 3rd to 20th year) of 35 Mg $ha^{-1}$ D.M. (50% w.c.) [50]. During the increasing production phase, the yield was 30% (1st year) and 80% (2nd year) of maturity phase, respectively.

Therefore, given that depending on the moisture of the harvested product the giant reed has essentially two market destinations, for economic and financial analysis the following biomass products have been considered:

- woodchip production (50% water content) destined to plants that generate electricity and/or heat, with an average annual yield of 35 Mg $ha^{-1}$ D.M.
- chopped forage production (70% water content) destined to biogas plants, with an average annual yield of 49 Mg $ha^{-1}$ D.M.

The market price of woodchip production was equal to 50 € $Mg^{-1}$ D.M. and it was determined as subrogation value of other lignocellulosic biomass crops with the same water content and similar calorific value [51–53].

The chopped forage market price was 35 € $Mg^{-1}$ D.M. and it was obtained as subrogation value of maize silage, considering that both crops have a similar bio-methane potential [54,55].

As regards the annual crops, the average yield of last four crop years was considered at the purpose of limiting possible variations due to weather trend or diseases. In particular, yield was 18 Mg $ha^{-1}$ for melon and 30 Mg $ha^{-1}$ for tomato, while market price was equal to 200 € $Mg^{-1}$ for both.

Financial analysis was performed by means of discounted cash flow (DCF) method [56–60] and in order to compare pluriennal crops with annual ones, as well as in other studies [61–64], annual gross margin (AGM) was determined, converting positive and negative cash flows to an average annual value.

In particular, as regards vineyard and giant reed plantations, considering that financial conditions over the whole period are constant [65], firstly the discounted cash flows generated from each investment for 20 years (lifetime of both crops) were