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ASPECTS REGARDING THE ENERGY POTENTIAL OF THE MISCANTHUS PLANT

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ABSTRACT

Greenhouse gases resulting from human activities are the most significant driver of climate change. The use of renewable resources obtained by cultivating energy plants, that have the potential of replacing fossil fuels, is one of the most important approaches to reduce the consequences produced by this global climate change hazard.

The paper presents information regarding the energy potential of the Miscanthus plant, that can be explored in three main directions: to produce bioethanol, biogas or solid biomass (chopped, pellets or briquettes), then use thermochemical processes for energy production.

INTRODUCTION

One of the effects of technological development in the last century is the pronounced increase in energy consumption, but also the increasing dependence of mankind on the consumption of fossil fuels, especially hydrocarbon products, natural gas and coal. These conventional energy sources represent a very high-risk factor due to pollutant emissions during combustion, and due to their depletion [4].

The costs of purchasing conventional fuels are increasing and they are dependent on less predictable factors. In this context we are attending to the increasingly clear perspective of the depletion of fossil fuel reserves, a perspective that has determined public entities to fund research, oriented towards identifying new energy sources. In addition to fossil fuels depletion, the problem of global warming, is the consequence of uncontrolled burning of highly polluting fuels for over a century [26].

The use of renewable resources by cultivating energy plants that might replace fossil fuels is one of the solutions for reducing the consequences of this global hazard. [20]

Energetic plants are considerend renewable energy resources and are promoted through cultures dedicated for energy yielding, obtaining high production with minimum inputs. [5]

Renewable energies have a less harmful effect on global environment, having much lower greenhouse gas emissions. The main objective of using renewable energy is actually the significant reduction greenhouse gas emissions [24].

Miscanthus (fig. 1) is considered a plant with high potential for the present time, since the issues regarding soil pollution are increasing and the non-renewable sources of energy are depleting fast [1].

Miscanthus is a promising bioeconomy crop with several biomass utilisation pathways. However, its current cultivation area in Europe is relatively low. This is most likely due to a lack of knowledge about the implementation of miscanthus into farming systems. [3]

Miscanthus has a strong yield potential through its low nutrient requirements and high efficiency in the conversion of solar energy into biomass, thus being suitable for marginal areas.

Fig. 1 - Miscanthus giganteus crop [30]

Native to Asia, miscanthus, also called ‘Giant Miscanthus’ was first brought into Europe in the 1930s. Miscanthus is a particularly promising crop plant thanks to its highly efficient use of nitrogen, water and sunlight. Reported applications of miscanthus biomass refer to (ranked by descending order of use in Europe): bioenergy (combustion for heat and electricity or gasification), building material (light concrete, wall and wind-protection covering, loam walls, insulation, roofing), car parts (steering wheels, oil binder), horticulture (pots, culture substrates, mulch and bedding for fruits and vegetables), and animal husbandry (horse bedding). [16]

Discussion of the economic, social and environmental impacts of biofuel production and use has centered on three aspects. Firstly, the net carbon reduction benefit of using bioenergy when the whole life-cycle energy balance, fossil fuel use and greenhouse gas emissions of production and transport are considered, secondly, the additional demand from direct utilization of food crops for liquid biofuels manufacture, or the potential for purpose-grown “energy crops” to compete indirectly with food production on agricultural land, together impacting on global food supplies or price, water and land availability - the so-called “land-fuel-water” nexus, thirdly, negative impacts on the environment through land use change or deforestation from biofuels production, or indirect land use changes from displaced agriculture [14].

MATERIAL AND METHOD

Miscanthus plant produces renewable resource 15-20 t / ha dry matter, has a perennial growth of 10-15 years, efficiently uses nitrogen, water and other resources, is disease resistant and require little fertilizer pesticides and other chemicals maintenance. Miscanthus stems can be used both as fuel for directly producing heat, or converted into other useful products such as biogas, bioethanol or biodiesel [19].

According to some experts from the University of Illinois (where the largest research institute in the U.S. has studied this plant), the main advantages provided by Miscanthus cultivation are:

- Miscanthus is a perennial, noninvasive;
- The land on which it is grown, can be regenerated fast food crops (corn, soybeans, beans);
- Allows obtaining large quantities of biomass with low costs and even free;
- It is excellent for soil carbon fixing and soli reconstruction [24]

Miscanthus is a dedicated biomass energy crop that can be used as an alternative energy source for biofuel production to decrease dependency on petroleum-based fuel sources [9].

According to the same experts, Miscanthus can annually generate a certain biomass quantity from which one can produce up to twice and a half more bioethanol than the quantity obtained from the corn biomass annually harvested on a surface of an acre (approximately 0.405 ha) [8]. A study achieved during 1997 – 1999 on 15 genotypes of Miscanthus sp. (*M. x giganteus, M. sinensis, M. sacchariflorus*), cultivated in different locations from England, Portugal, Denmark, Sweden and Germany have emphasized its extraordinary ecological plasticity. Thus, the studies have shown that the viability of plantations of Miscanthus giganteus and Miscanthus sacchariflorus is minimum when the soil temperature decreases under the limit of – 3 °C at a depth of 3 cm. In Great Britain and Germany, the best performances were given by Miscanthus giganteus. In Portugal, although very good results were obtained also for Miscanthus giganteus, a hybrid of Miscanthus sinensis was the most efficient. Always, a series of hybrids of Miscanthus sinensis has obtained the best results in Sweden and Denmark climate. The study' authors concluded that Miscanthus sinensis presents an extremely good capacity of growing in various climate conditions, while for the Central Europe, *Miscanthus giganteus*, represents the most performant genotype [25].

Biomass is the bioenergy carrier and can be converted to solid, liquid and gaseous fuels. Biomass helps reduce the consumption of fossil fuels, helps decrease greenhouse gas emissions and has the advantage that it can be easily obtained. [7] Miscanthus, a plant type with high biomass yield potential, is a promising feedstock source for bioenergy production. However, the current expansion of miscanthus (Miscanthus spp.) production is constrained by a shortage of commercial varieties, especially those suitable for different energy usages and cultivation under adverse environmental conditions. Therefore, breeding or selecting high-biomass-yielding, high quality and stress tolerant miscanthus varieties is essential for the extension of miscanthus for bioenergy production. To effectively select elite germplasms and breed new varieties of miscanthus, it is necessary to establish a scientific evaluation method for analysing their energy potential [23].

Regarding the use of energy crops in anaerobic fermenters for biogas obtaining, a group of researchers assessed different energy crops (Miscanthus x giganteus, sorghum, sunflower, tall fescue, spelt, hemp, switchgrass and immature rye) as an alternative to the use of maize as substrate. Experimental results have shown that the perennial crop Miscanthus x giganteus is the most promising alternative to maize in anaerobic fermentation process, if it is harvested as green matter in autumn, with a production of biogas of $5.5 \pm 1x\ 10^3\ m^3\ ha^{-1}$, as compared to $5.3 \pm 1x\ 10^3\ m^3\ ha^{-1}$ for maize. [6]

Miscanthus species are important energy crops, due to their high yield of biomass, used for combustion, biofuel fabrication and as a feedstock for various products. They can be also utilized for phytoremediation and other ecological programs. Extensive needs require considerable amounts of planting material [2].

În general, plant propagation can be achieved by 3 methods: seeds, micro-propagation and division of rhizomes.

In Europe, commercial propagation of Miscanthus by seed is unlikely due to several considerations such as:

- The growing season in northern and central Europe is too short for Miscanthus to produce mature and fertile seeds [12].
- M. x giganteus is an interspecific triploid hybrid and is therefore practically sterile. In situations where fertile seeds are produced (southern Europe, greenhouses in northern and central Europe), the morphology of the descendants is variable [13].
- Even if fertile and genotypically stable seeds could be obtained, direct seed sowing in the field in spring seems to be inefficient for northern and central Europe, due to intolerance of young seedlings to low winter temperatures. The Danish Institute of Agricultural Sciences (DIAS) reports that when the seedling survives, it takes several years for the crop to stabilize and therefore requires large herbicide inputs during this period to control weeds in the crop maintenance phase.

Given the pedoclimatic conditions of culture, of all the genotypes of Miscanthus, the one that is of interest for our area is *Miscanthus giganteus*.

Being a sterile hybrid, it cannot propagate through seeds and as a result for this genotype the last 2 propagation methods are viable, by micro-propagation and division of rhizomes.

Micro-propagation can provide a very high multiplication factor (up to 2000) [12], but these propagation techniques are currently more expensive. Crops established using the micropropagation method are more sensitive to less favorable conditions (e.g. dry summers).

Rhizome division method is preferred because it is less expensive and generally produces more vigorous plants (Fig. 2).

Rhizome fragments should have at least 2-3 burgeons and should be kept moist before replanting. This can be done by keeping the rhizomes in storage conditions with low temperatures (<4ºC), but they will remain viable in the field for a short time, if they are stored in piles and covered with moistened soil.

Fig. 2 - Miscanthus rhizome division and multiplication process [18], [29], [28]

Fragments of mechanically divided rhizomes can be collected with a potato or bulbous plants harvester, from the nursery, planted with a density of 3-6 plants / m^2. After 2-3 years, the nurseries are subjected to a tillage work with a rotary cultivator in a single pass, dividing the rhizomes into fragments of 40 to 100 grams. This operation leads to a multiplication factor of approx. 50 compared to a multiplication factor of 100 obtained by manual cutting of rhizomes from whole plants [17].

RESULTS AND DISCUSSIONS

There are a number of energetic and material utilization pathways for miscanthus biomass. Combustion, ethanol production and anaerobic digestion are three energetic pathways, while animal bedding and lightweight concrete are examples of material end uses [14]. Combustion is currently the most common utilization pathway in Europe. In figure 3 it is shown Biomass yield of miscanthus in Europe, between different Miscanthus species.

A comparison between different Miscanthus sp. shows that *M. giganteus* yields are higher than those of *M. sinensis* and *M. sacchariflorus*.

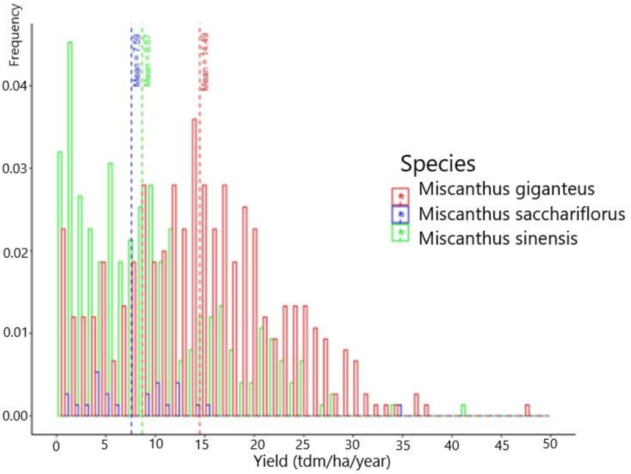

***Fig. 3. Biomass yield of miscanthus in Europe. Red vertical lines denote the averages. Values obtained from the "global yield dataset for major lignocellulosic bioenergy crops based on field measurements* [16]**

Miscanthus was recently been found to be a promising biogas substrate that can substitute or complement maize. However, for biogas use, miscanthus has to be 'green' harvested in late autumn [15].

Conventionally, miscanthus is harvested 'brown' after winter when the biomass is dry and most suitable for combustion and animal bedding. A 'green' harvest conducted between (mid-) October and early November leads to higher nutrient and moisture contents in the biomass, accompanied by a lower lignin content. A 'brown' harvest after winter, in March, provides lignified miscanthus biomass with low moisture and nutrient contents. High lignin contents increase the recalcitrance of the biomass [22], [10] and thus reduce the efficiency of fermentation processes [21]. On the other hand, higher lignin contents are preferable for combustion, due to the higher heating value of lignin [8]. Brown-harvested miscanthus has a heating value of 17–20 MJ/kg [20], with low potassium and chloride contents as well as a low ash sintering index, reducing corrosion and fouling of the burning utility [16]. Depending on the harvest date, miscanthus x giganteus can achieve dry matter (DM) yields of up to 22 t/ha when brown-harvested and up to 27 t/ha when green-harvested. This difference can be explained by leaf fall over the winter, leading to a yield reduction [23].

CONCLUSIONS

Conventional energy sources represent a high-risk factor due to the pollutant emissions, resulting from combustion, as well as due to their depletion.

One of the most efficient solutions for replacing fossil fuels and reducing the level of CO_2 emissions is the use of renewable sources of energy, characterized by a very extremely low level of these emissions.

This paper underlines the advantages of miscanthus cultivation: It is an economically viable crop with multiple feasible utilisation options. Miscanthus cultivation provides biomass for a number of utilisation pathways and, with its low-demanding and perennial nature, at the same time benefits soil and water quality.

Depending on the harvest date, *Miscanthus x giganteus* can achieve dry matter (DM) yields of up to 22 t/ha when brown-harvested and up to 27 t/ha when green-harvested.

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