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journal homepage: www.elsevier.com/locate/rser

An overview of biofuels from energy crops: Current status and future prospects ☆

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ARTICLE INFO

Article history:

Received 3 October 2012

Received in revised form

3 August 2013

Accepted 11 August 2013

Keywords:

Energy crops
Sweet sorghum
Switchgrass
Biofuels
Bioethanol
Biodiesel
Biogas

ABSTRACT

Energy crops constitute significant potential for meeting the future energy need worldwide. In addition, agricultural lands offer an alternative to the agriculture which is referred to as energy farming. The studies on energy crops in biofuel production show that they are quite an economical and environmentally beneficial way of sustainable energy production. Today most of the developed countries use staples such as corn, sugar beet, soybean, rapeseed, and wheat in order to obtain energy. Moreover, bioethanol is mostly produced from sugarcane and corn and biodiesel from oilseed plants. Therefore, these produced raw materials compete with food and feed production. Consequently, the use of those energy crops which are used as food products for biofuel production is an important issue which must be considered in terms of the current food safety. Some energy crops, such as miscanthus, switchgrass and sweet sorghum, that are called C4 crops, can grow with high biomass yield even in infertile land. Thus, these crops are used in energy farming – a new type of agriculture. Furthermore, C4-type crops possess the features of resistance to aridity, high photosynthetic yield and a high rate of CO₂ capture when compared with C3 crops. In conclusion, C4 crops tend to produce more biomass than C3 crops. Therefore, these crops are investigated, focused on, and elaborated on in this paper.

This study aims to present a comprehensive review on the production of biofuels from lignocellulosic agricultural products and promising energy crops. Thus, the energy crops to be used as raw materials for biofuels today and in the future are investigated. In addition, it is intended to highlight the energy crops used as staples by discussing them in detail for biofuel production. The energy crops which are promising in biofuel production, particularly non-staple miscanthus and sorghum, are presented in detail as they are non-food crops and have a high yield. Furthermore, the energy crops used as raw materials for bioenergy today and their potential are compared both worldwide and in Turkey.

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1. Introduction

The use of biomass to produce energy is only one form of production of renewable energy that can be utilised to reduce the impact of energy production and use on the global environment [1].

Biomass has the largest potential and can only be considered as the best option for meeting the demand and insurance of future energy/fuel supply in a sustainable manner. The modernization of biomass technologies leading to more efficient biomass production and conversion is one possible direction for efficient utilization of biomass resources. Agricultural biomass is a relatively broad category of biomass that includes the food based portion (oil and simple carbohydrates) of crops (such as corn, sugarcane, beets) and the non-food based portion (complex carbohydrates) of crops (such as the leaves, stalks, and cobs of corn stover, orchard trimmings, rice husk, straw), perennial grasses, and animal waste [2].

Energy can be obtained from biomass in five ways: production of crops which yield starch, sugar, cellulose and oil; solid waste which can be burnt; anaerobic digesters which produce biogas which can be used to generate heat/electricity; landfill production for methane; and biofuel production which includes ethanol, methanol, biodiesel and their derivatives [3].

Today, there are strong incentives to encourage an increased use of renewable fuels in the transport sector worldwide. Incentives exist within energy, climate and agricultural policies in several countries to promote further progress in the use of biofuels [4].

Every year our earth's atmosphere receives more than 15 billion tones of CO₂. The combustion of fossil fuels is a big contributor to the increase in the level of CO₂ in the atmosphere which is directly associated with global warming [5,6].

One of the major drivers for worldwide biofuels development is the concern about global climate change that is primarily caused by the burning of fossil fuels. There is substantial scientific evidence that the accelerating global warming is a cause of greenhouse gas emissions. One of the main greenhouse gases is carbon dioxide [7].

Plant biomass has been known for decades to be one of the most promising renewable energy sources that can be used for production of biofuels, since it is an abundant resource, has low CO₂ emissions and low cost. Biomass provides approximately 14% of the total world-wide energy needs and represents an important contributor to the world economy. Furthermore, plant biomass can contribute to a stabilization of farmers' incomes, and can maintain and improve ecological and social sustainability [8].

Today the production of biofuels from biomass as a renewable energy resource is quite important since it is both a clean energy resource and related to the environment, economy, agriculture, and rural development. Moreover, the development of biofuels from energy crops has a critical role in the development of the world economy and the reduction of global climate change.

This paper intends to summarize the current status of, and the future perspective on, the production of biofuels from the energy

crops used as raw materials both worldwide and in Turkey. Additionally, it also encompasses the classification of energy crops as raw materials for biofuels all around the world, their potential for production, characteristics of the new promising energy crops, and their status in the future.

2. Current biofuel production in the World

In 2010 worldwide biofuel production reached 105 billion liters (28 billion gallons US), increasing by 17% from 2009, and biofuels provided 2.7% of the world's fuels for road transport, a contribution largely made up of ethanol and biodiesel [9].

Biofuel consumption in transport continued to increase in the European Union. As it can be seen from Table 1, it stabilised at around 13.6 Mtoe (millions of tones of oil equivalent) in 2011, compared to 13.2 Mtoe of consumption in 2010. It is too early to say whether all this consumption meets the Renewable Energy Directive's sustainability criteria, because the majority of the sustainability systems were yet to be set up in 2011 [10].

Table 1 shows biofuel consumption for transport in the European Union in 2010 and also, Table 2 shows biodiesel production in the European Union between 2009 and 2010 [10].

Table 1

Biofuel consumption for transport in the European Union in 2010 (in toe) [10].

Countries	Bioethanol	Biodiesel	Others	Total consumption
Germany	746,776	2,281,791	53,908	3,082,475
France	490,112	2,138,627	–	2,628,739
Spain	233,179	1,192,627	–	1,425,807
Italy	139,940	1,254,013	–	1,393,953
United Kingdom	316,495	823,660	–	1,140,155
Poland	187,184	710,713	3180	901,078
Austria	63,457	354,858	119,175	537,489
Sweden	203,943	198,340	49,355	451,638
Belgium	52,119	305,917	–	358,036
Portugal	0	325,982	–	325,982
Czech Republic	61,262	172,494	–	233,756
Romania	45,142	185,583	–	230,725
Netherlands	134,136	94,559	–	228,695
Slovakia	45,142	132,560	–	177,701
Hungary	57,615	117,009	–	174,625
Finland	73,517	62,745	58	136,320
Greece	0	124,810	–	124,810
Ireland	27,324	79,249	2036	108,610
Lithuania	10,412	34,731	–	45,144
Slovenia	2904	41,724	–	44,628
Luxembourg	720	40,043	–	40,763
Denmark	34,179	820	–	34,999
Bulgaria	0	34,387	–	34,387
Latvia	8419	18,698	–	27,117
Cyprus	0	14,944	–	14,944
Malta	0	884	–	884
Estonia	0	0	–	0
Total EU 27	2,933,977	10,741,771	227,712	13,903,460

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