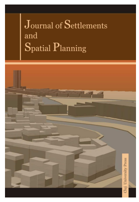
Centre for Research on Settlements and Urbanism
Journal of Settlements and Spatial Planning
Journal homepage: http://jssp.reviste.ubbcluj.ro



Establishment of an Agricultural/Biofuel Feedstock Research Field Station in Rural South-Carolina

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Keywords: *alternative fuels, biofuel feedstock, rural development*

ABSTRACT

Today's worldwide growing interest in biofuels production, in obtaining higher biomass yields, and in providing cleaner liquid fuels for an affordable price could lead to results that might positively solve known present concerns related to global warming and decreasing petroleum fuel resources through the use of the natural rural landscapes. Grass biomass can be converted to bioenergy using technologies such as: conversion to liquid fuels (ethanol); combustion alone or in combination with fossil fuels to produce heat, steam, or electricity; and gasification. This paper presents our efforts in establishing an agricultural/biofuel feedstock research field station in the rural area of the Orangeburg County, South Carolina, geared towards establishing, equipping, and staffing mass production of biofuel feedstock. Since there is a growing interest in using perennial grasses as renewable fuels for generating electricity and for producing bio-ethanol, four crops (Sugarcane, Miscanthus, Sorghum, Sudan grass) have been selected for use in biomass production. All these crops are going to be harvested in two different fields: the organic field (environmental sustainability/organic farming) and the non-organic field. Each field has approximately 15 acres (60702.85 m^2) while the experimental design used for the data collection is going to be the Randomized Complete Block Design. So far, the first step in the crops establishment was to take soil samples for scientific analysis which were sent to Palmetto Agri-Services, York, SC. The plot was mapped out using a GPS program and 40 soil samples holes were collected from each field. Our project's mission is to identify the most suitable crop for the local climate and soil while advancing knowledge for agriculture, the environment, human health and the well being of rural communities. Biofuel production from these four crops might be extended to other agricultural areas, namely rural areas in countries like Romania and other developing countries where there is a large number of non utilized agricultural fields as well as access to European funds and relatively cheap labour. It might constitute an innovative way of revitalizing and developing remote rural areas.

1. INTRODUCTION

Due to the lack of sustainability in the case of fossil resources as related to their effects on the economy and the environment, biofuels represent an advantageous alternative for the replacement of fossil fuels. Also, because of the world increasing demand for oil based products and of the limited fossil fuels resources, increasing and finding alternative fuels represents the new challenge of the 21st century.

Biofuel is a term used for a wide range of fuels that must have a biomass origin. Therefore, the use of biofuels can play an important role in avoiding the excessive dependence on fossil fuels and also improvise the environmental sustainability [11].

According to the 2008 FAO report, liquid biofuels used for transportation had the highest growth in spite of their limited volume (fig. 1), being obtained through agricultural and food commodities (e.g. feedstocks). Liquid biofuels can be classified in three groups: first, second, and third generation of biofuels.

The first-generation is represented by biofuels produced using sugar, starch, vegetable oil. This generation of biofuels includes biodiesel, bio-ethanol and biogas, all of these having the ability to be used as blended with petroleum-based fuels or as fuels without any blending [23]. Most of the first-generation bio-fuels rely on food crops, mainly corn and soy used for production of bio-ethanol in the USA. Sugarcane is another crop used for production of bio-ethanol in Brazil, sunflower and rapeseed being the most popular crops for the production of bio-diesel in Europe.

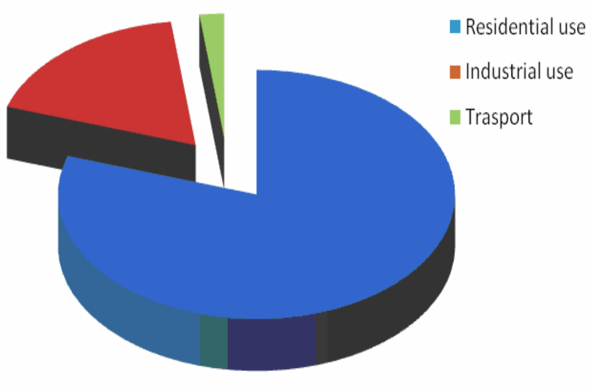

Fig. 1. Use of biomass for energy in 2007.

The major concern regarding the production of the first generation of biofuels is related to the impact that these crops may have regarding land use and competition with food crops. In order to obtain biofuel from these crops it is necessary to ferment the sugars or break down the fatty oils through transesterification. One of the most important assets of the first generation of biofuels consists in helping with the reduction of the greenhouse gas emissions by 20-70%, as compared to petroleum fuels [13].

The second-generation of biofuels use lignocellulosic biomass as feedstock from non-food crops, among which one can name biofuel crops like miscanthus, sudan grass, switchgrass and agricultural residue such as corn stalks that can all be converted via two main pathways: a biochemical and a thermochemical conversion or direct combustion. Biochemical conversion is a process which uses the metabolism of micro-organisms and where biomass conversion is more efficient in terms of nutrients and organic matter recycling [25].

Biomass resulted from all these crops can be utilized using designed microorganisms, which can break down cellulose and lignin to reach the sugars contained in the biomass. This step is used to retain the "cellulosic ethanol". Genetically modified anaerobic microorganisms can also be utilized to transform biomass into biogas and biohydrogen, via a process known as anaerobic digestion.

Thermochemical conversion is a process where biomass was converted into charcoal, oil and gas under high temperature and absence of oxygen. These outputs show an alternative to liquid biofuels which are similar to petroleum oil [16]. The thermochemical pathway converts biomass to biofuel using combustion, gasification and fast-pyrolysis processes.

The third-generation of biofuels includes fuel that is made from genetically modified oilier crops (e.g. poplar trees with lower lignin content for easier processing), or from algae. Microalgae are a renewable energy source which has not been fully exploited, and also suggested as the best alternative for fuel production compared to the other species and crops. Mature, oil-rich algae can be processed into a number of commercial products such as Biodiesel (oil), Ethanol, Animal Feed, Food, Cosmetics, Pharmaceuticals and Plastics (Biodegradable). Although many species produce useful compounds naturally, these unicellular organisms are also well suited for genetic manipulation and also generated high interest in producing valuable molecules ranging from therapeutic proteins to biofuels. The most important microalgae are diatoms *(Bacillariophyceae)*, green algae *(Chlorophyceae)*, blue-green algae *(Cyanophyceae)* and golden algae *(Chrysophyceae)*.

According to the Organization for Economic Co-Operation and Development Food and the Agriculture Organization of the United Nations Agricultural Outlook report, US ethanol production was assumed to grow by almost 50% in 2007 (the actual growth was of 43%), growth mostly based on domestic maize. Ethanol production of US is still assumed to double between 2006 and 2016. According to the same source, bio-diesel production was assumed to remain relatively limited in the US because of the lower profitability caused by high feedstock costs. After reviewing the most recent FAO statistics, one can observe a 220.28% increase in the USA ethanol production over the 2005-2011 time period, at the same time with a 721.56% bio-diesel production increase report (table 1).

Table 1. Production of sunflower and rapeseed.

Rank	Commodity	Production (Int $1000)	Production (MT)	Country
1	Sunflower seed	116,030	546,922	Romania
2	Rapeseed	101,643	361,500	Romania
3	Sunflower seed	1,025,461	4,773,579	E.U.
4	Rapeseed	4,819,528	18,431,154	E.U.

Comparatively, the EU bio-fuel production and use was based on oilseed (rapeseed). Slowly, the ethanol production started to gain market and reveal interest of the EU with an approximate 156.36% increase in 6 years. However, even if total biofuel use grew by some 170% between 2006 and 2010, it is assumed that bio-fuels in total transport fuel consumption will not exceed 3.3% in energy terms, rather than the 5.75% target set by the EU Biofuels Directive for 2010 [24]. Germany is the only EU member who might achieve the target, having 8.37% share of bio-fuels in fuel consumption of transport in 2007 according to the Eurostat data. Further growth is, however, expected throughout the projection period (fig. 2 and 3).

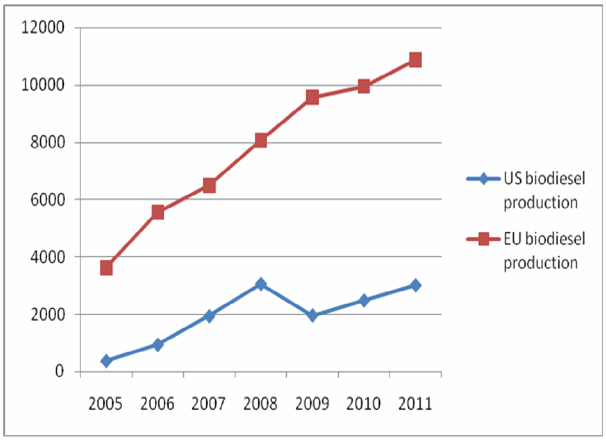

Fig. 2. Total ethanol projection (US vs. EU).

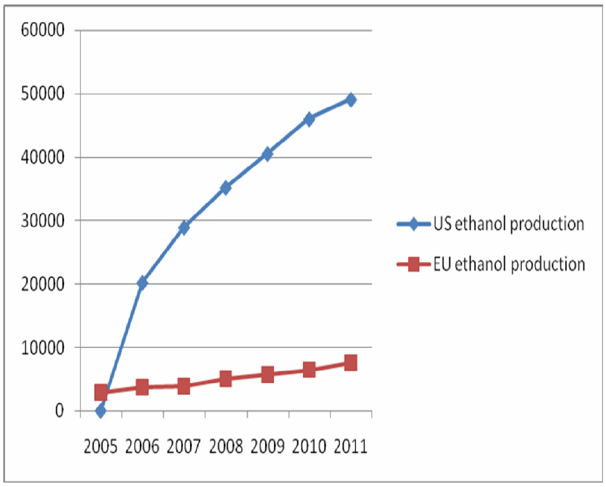

Fig. 3. Total biodiesel projection (US vs. EU).

According to the FAO official data from 2007, the production of sunflower seed in Romania represents 11%, respectively 1.96% for rapeseed from the total production recorded in the E.U. for these crops (table 1). According to Fischer et al., 2005, Romania has a bio-energy production potential that will exceed the current commercial energy use by 122%. From this data we can clearly conclude that Romania has a lot of potential as far as biomass production.

2. MATERIAL AND METHOD

The field trial was performed at the Heat Hill farm site in the rural area of the Orangeburg County, South Carolina on Sandy Loam soil type. The "traditional" agriculture field is located at 33.83°N latitude and 80.69°E longitude, the organic field having the following coordinates: 33.84° N latitude, 80.68° E longitude. The long-term average annual air temperature is 17.5°C with total precipitation of 1203.20 mm. The initial crop before the trial in both fields consisted of corn. Sugar beet will be sown as a winter crop after the annual crops will be harvested.

The first step in the crops establishment was to take soil samples for scientific analysis, then send the samples to Palmetto Agri-Services, York, SC. The plot was mapped out using a GPS Agfleet software program, 40 soil samples being collected from each field. Consequently, four crops were selected (miscanthus, sudan grass, sorghum and sugarcane) to be planted on both fields, each crop being planned with four replications in each field. The experimental design used to interpret the data will be the randomized block design.

Giant Miscanthus (*Miscanthus* x *giganteus*) is a perennial rhizomatous sterile hybrid, warm-season Asian grass showing great potential as a biomass crop in USA and Europe. Research fields trials of Giant Miscanthus have produced greater yields than switchgrass in US or oily seeds crops in EU. Miscanthus x giganteus has been studied in Europe between latitude 37°N and 56°N according to David M. Burner, 2009. Also, Miscanthus has been grown in the European Union on a large scale for more than 20 years with no evidence of becoming invasive [20], usually major concern for the US researchers. According to different publications yields of M. x giganteus dry matter have been found to range between 5 and 44 t ha^{-1} per year $^{-1}$, variation being due to the location of the field trials (central and northern/southern parts) and rainfall amounts [19, 21, 28, 22]. When Miscanthus yields were compared to switchgrass yields it was found a three up to four times higher yield in Miscanthus plants [14]. Plant rhizomes can be planted approximately 4-inches deep and 3-feet apart within rows and 3-feet between rows. In Europe several studies have shown that Miscanthus does not respond to N fertilization from the second or third year onwards. It was tested that a quantity of 60 kg N ha^{-1} if it is applied in the first year and 50 kg N ha^{-1} in the second year is sufficient for a high biomass yield. As far as P and K application, they need to be applied at rates sufficient to replace the nutrients taken up by the plant. As far as herbicide application, they need to be administrated only in first year and they are not required in the following years. Harvest period for Miscanthus is in the winter period, between December and March, when plants are dormant [22].

Sugarcane is a tropical perennial grass that grows well in humid areas with a temperature range between 70-95°F, belonging to the genus *Saccharum*, and is usually grown within latitude 30°N and 35°S, and planted in fall [29]. Sugarcane is an important crop for many tropical and subtropical regions worldwide, being also cultivated in southern regions of US, namely: Florida, Texas, Louisiana, and Hawaii. Sugarcane is among the most efficient crops in converting solar energy into chemical energy and has a favourable total energy output per unit of energy required to produce the crop [9]. It is vegetatively propagated using a section of a mature cane stalk which has one or more buds. Sugarcane stalks can be planted as a single row or multiple rows with a 4-8 feet distance between the rows. Plants will be ready for harvesting after November 1st of the following year [22].

Sudan grass (*Sorghum bicolor var. sudanese*) and sweet sorghum (*Sorghum bicolor* L. *Moench*) are two annual plants belonging to the same Genus, Sorghum.

Sweet sorghum has the optimal growth temperature range from 80-86ºF and can tolerate temperature as low as 44-50°F. Some of the sweet sorghum varieties in favourable environments can grow 14 feet tall while sudan grass can grow approximately 6 feet tall. Both crops are agricultural energy crops due to high yields, drought tolerance and low input requirements [1]. Due to the high content of fermentable juice expressed in these plants, ethanol production is also high, between 6,000 and 8,000 l/ha and has an energy efficiency of 1:8 [1], [30]. Sweet sorghum fresh biomass production range between 52 t/ha under dry land conditions up to 83.1 t/ha under irrigated condition [4], [25], while sudan grass can produce between 30-80 t/ha of fresh forage [8]. After crops establishment harvest will be carried out in fall, for perennials crops and two-three times for the annual crops depending on the weather conditions.

The agricultural machinery for the farm work includes a tractor (John Deer 8530) and the above mentioned soil cultivation, planting, sowing and direct seed-drilling machines, a John Deer 9860 fertilizer distributor, with a width of 25 ft (seed capacity 1,500 kg) and a pesticide sprayer that contains 300 gal.

3. RESULTS AND DISCUSSION

After receiving the soil testing reports (fig. 4 and fig. 5) we interpreted the data using the table from Clemson Public activities website. According to the fertilization recommendations offered by Clemson University, 112 ha^{-1} of N, 28 t ha^{-1} of P_2O_5 and 67 ha^{-1} of K_2O was applied to all plots in March 2010 before establishing the field trial.

After 1989 Romania was dealing with rising unemployment, situation similar to what was happening at the end of the 1970s in the Swedish economy. Declining economy was affecting all working classes, young people new to the labour market as well as older people close to retirement. During the recession period in Sweden many agricultural programs were initiated for job creation through the intensification of forestry activities, most of the affected employment being in agriculture and forestry [15]. According to the EU-27 2009 Annual Report, 90% of the bioenergy comes from the forestry sector, which proves that the programs implemented in 1970s worked; therefore similar programs might be implemented in the Romanian rural areas [3].

Diversification of crop uses and the initiation of new biofuel crops would lead to enhanced farmers' incomes, help rural development and protect the environment. Biofuels produced from agricultural biomass represent a renewable and eco-friendly source which offers opportunities to improve the income level and can help with the developing of small farmers (US, Romania and all over the world) which usually depend on agriculture for their living and food consumption.

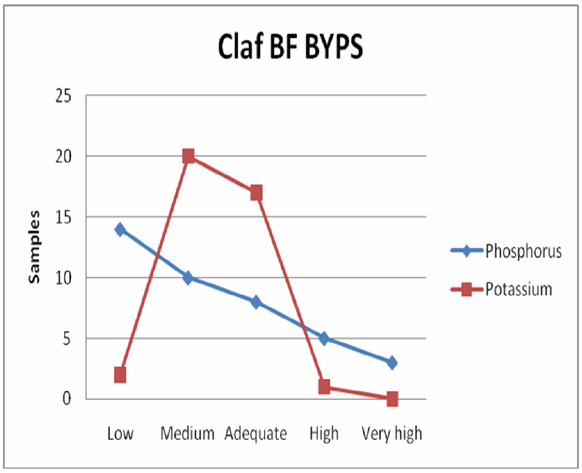

Fig. 4. Soil analysis report for the traditional field.

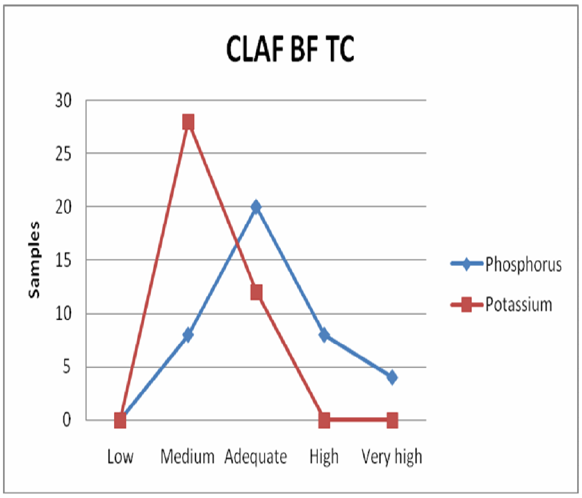

Fig. 5. Soil analysis report for the organic field.

4. CONCLUSION

The establishment of an agricultural/biofuel feedstock research field station facility would be based to some extent on local resources and needs, but the money generated would remain in the local economy. By using biomass production crops (such as sweet sorghum) under a dry land conditions, a farmer might make with 23% more money just by replacing the grain sorghum and by growing the biomass crops [2].

By cultivating biomass for biofuels production, a large surface from the non utilized agricultural fields, found in most of the former communist countries, and also the access to European funds and relatively cheap labour will help in the development of the rural areas.

5. ACKNOWLEDGEMENTS

The authors thank Claflin University for the opportunity to conduct this research and U.S. Department of Agriculture (USDA) for funding the project.

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