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PLANTATION OF ENERGY PLANTS AS AN ELEMENT OF THE LANDSCAPE PROVIDING THE ECOSYSTEM SERVICES

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Abstract

Earth's ecosystems provide for humanity full range of benefits known as ecosystem goods and services. By the processing of information was used the methodology of Millennium Ecosystem Assessment (4 groups of ecosystem services). The paper assessed the first group of services - provisioning services with the possibility of using agricultural lands for growing energy plants. In the paper are evaluated the energy plant Miscanthus and Populus. The crop Miscanthus (covered 2010-2014) presented two genotypes. In 2012 (the third year of growing) has been reached the production of 24.85 t ha^{-1} (60% more than in 2011). In 2014 (the fifth year of growing) the crop reached production 28.60 t ha^{-1} of dry biomass. The plantations Miscantus × giganteus genotype planted the rhizomes are appeared productive. Fast-growing poplars Italian provenance, in the first three-year cycle in 2012 formed 51.47 t ha^{-1} of biomass. In 2014, the second year of the three-year harvest cycle average value of their biomass was 34.40 t ha^{-1}. Based on an assessment of production above-ground organs monitored varieties of poplar are more productive varieties Monviso and Pegaso. Based on the evaluation of the ability of energy plant plantations (grasses genus Miscanthus and woody plant of the genus Populus) to produce enough above-ground biomass for energy use can be confirmed the high prevision service of this type of cultural ecosystem (agro-ecosystem).

Key words: *agroecosystem, ecosystem services, energy crops, Miscanthus, Poplar, provisioning*

INTRODUCTION

Ecosystems are the basis of all human life and human activities. The goods and services which provide are essential for maintaining prosperity as well as for future economic and social development. At the ecosystem level we register the complex and dynamic combination of plants, animals, micro-organisms and the natural environment, existing together as a unit and the parts depend on each other. Earth's ecosystems provide for humanity full range of benefits known as ecosystem goods and services – provisioning, supporting, regulating and cultural ecosystem services.
Ecosystem Assessment is a tool for evaluating the many different aspects of ecosystem health and the provision of ecosystem goods and services. In 2000 the United Nations started a global initiative called the Millennium Ecosystem Assessment. The report from this assessment indicates that up to two thirds of ecosystem services on Earth are threatened or in decline [13].
Natural ecosystems and agroecosystems differ in the intensity of their management and in the resulting consequences for their physical and biological components. Yet, they provide a range of goods and services that may be of interest for various stakeholders on various space and time scales.
Traditionally, agroecosystems have been considered primarily as sources of provisioning services, but more recently their contributions to other types of ecosystem services have been recognized [13]. Influenced by human management, ecosystem processes within agricultural systems can provide services that support the provisioning services, including pollination, pest control, genetic diversity for future agricultural use, soil retention, regulation of soil fertility and nutrient cycling. Whether any particular agricultural system provides such services in support of provisioning depends on management, and management is influenced by the balance between short-term and long-

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term benefits.

Cultivation of energy crops is alternatives with higher net greenhouse gas reduction and less impact on many ecosystem services than conventional crops. According to [8], biomass production based on energy plants allows for the minimization of such inputs as fertilizers, tillage or herbicide use. Short-rotation coppices also increase structures in intensively used agricultural areas, and provide space for nesting birds [10]. They may also increase scenic qualities and contribute to a green infrastructure [11] in intensively-used agricultural landscapes.

Agro-ecosystems are recognised in the international ecosystem services literature for their potential to contribute to the supply, of provisioning services, and also cultural, regulating and supporting services [17] and [15]. The major ecosystem services and ecosystem dis-services to agriculture are described in Figure 1. How agro-ecosystems contribute to, or impact on, the supply of ecosystem services depends on the management of those systems [7].

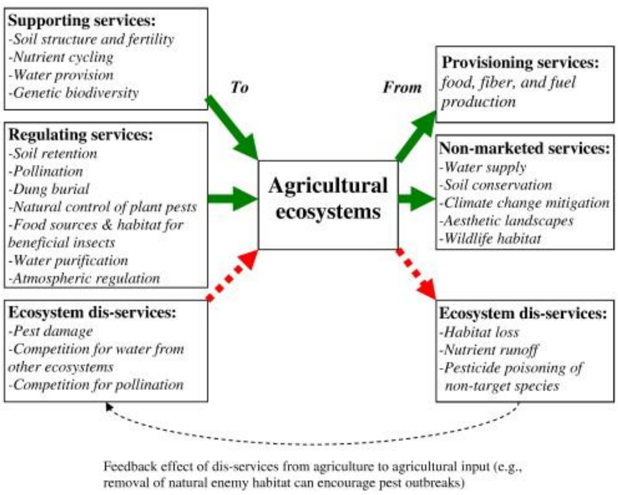


Fig. 1. Ecosystem services and dis-services to and from agriculture. Solid arrows indicate services whereas dashed arrows indicate dis-services [17]

The concept of agroecosystem services has become an important tool for modelling the interactions between agroecosystems and their external environment in condition of global bioclimatic changes.

The aim of this paper is to evaluate the potential of energy plants plantations in relation to the diversity of the country and identifying the contribution of these cultural ecosystems in the provision of ecosystem services in the landscape.

MATERIALS AND METHODS

As a basis for assessment of the ecosystem services of agro-ecosystems - energy plants plantations, serve the methodology of the European Environment Agency (EEA) Experimental framework for assessment ecosystem services in Europe [5] and Methodology for mapping and evaluation of ecosystems and their services [12].

Millennium Ecosystem Assessment divides ecosystem services into four basic groups - provisioning, supporting, regulating and cultural ecosystem services. The subject of this evaluation is the first group of services - provisioning services. Provisioning services are evaluated in terms of supply of energy resources serving as bioenergy. In this case, this is the cyclic provision of phytomass and woody biomass of the energy crops grown by plantation way.

In the paper are evaluated energy plants *Miscanthus* and *Populus* in term of their production capabilities in the process of adaptation to environmental conditions in the Slovak Republic.

The research area of energy plants was based on area of the University agriculture farm in the village Kolíňany (Slovakia) from 2009 to 2010.

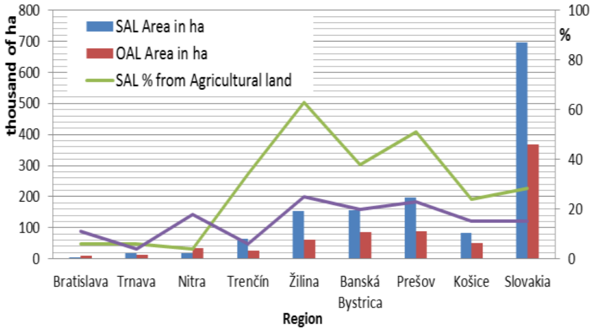
Genus *Miscanthus* represents two genotypes: *Miscanthus sinensis* Tatai and *Miscantus* × *giganteus*. The characteristics of genotypes are referred to in the work [9] and [14]. Method of in vitro propagation (*Miscanthus sinensis* Tatai) is disclosed by [6].

The genus *Populus* (poplar) representing the four Italian varieties: Monviso, Pegaso, AF-2 and Sirius. The characteristics of each variety are processed in work [2].

RESULTS AND DISCUSSIONS

Agro-ecosystems are natural human-managed systems with the main objective of obtaining food and other non-food and environmental services. In Slovakia is 49.16% of the

agricultural land - agroecosystems.
Slovakia needs to have 1,367,853 hectares agricultural land as a minimum area for food self-sufficiency, which represents about 56% of currently registered agricultural land of Slovakia [16]. On these soils can be achieved the best economic results from field crops, therefore, for strategic reasons should be left to direct agricultural use. It is the primary agricultural land. Land resources further comprise a secondary land, particularly arable land on which is supposed more profitable cultivation of agricultural crops. Secondary soil can be temporarily used for other purposes than food production, assuming the interests of society. This land can be allocated to alternative agricultural uses such as bio-energy. Secondary agricultural soil occupies 696,038 hectares, which represents about 29% of currently registered agricultural land of Slovakia (Figure 2). Within agricultural lands, there is also the other soil that should be used in preference to alternative agricultural use, for energy plants, at various non-biological purposes (sports, tourist and recreational). Other agricultural land occupies 368,587 hectares, which represents about 15% of currently registered agricultural land of Slovakia. Not only area of possible agricultural land plays an important role in the establishment for plantations of energy plants. The climate parameters are important element. Possibilities for using agricultural land for cultivation of the energy plants depend on the characteristics and habitat eligibility for the given plant. Considering the sufficiency of land to assign food security in Slovakia can be a relatively large part of agricultural land also used for cultivation of the energy plants. Temporary allocation of agricultural land for cultivation purposes of non-agricultural crops should be conditional on elaboration and especially the execution of a project retrospective reclamation. These plantations of energy crops create positive cultural ecosystem (agroecosystem) in agricultural landscape. The cultural ecosystem – plantation of energy plant provides the entire spectrum of ecosystem services. The main asset of plantations of energy plants is their productive potential - the provisioning ecosystem services. The production potential of the above-ground biomass can be used in bio energy as an alternative energy source.



Legend: SAL – secondary agricultural land; OAL – other agricultural land

Fig. 2. Area of the agricultural land usable for the cultivation of energy plants in Slovakia regions
Source: Own Processing by data from Slovakia National Agriculture and Food Centre (2016)

In the present paper are evaluated ecosystem services plantations of energy plants on the basis of provisioning ecosystem services. The yield of the biomass was evaluated by fast-growing trees and herbs grown on arable land. The biomass yield is expressed in terms of biological yield of the above-ground organs. The *Miscanthus* growth was studied in terms of biomass production in the period 2010-2014 (Table 1). The highest increases of the biomass were generated (both *Miscanthus* genotypes) in the third growing year (2012). There was achieved average yield 24.85 t ha^{-1}, which compared to year 2011 increased by almost 60%. After the fifth year growing (2014) the growth reached average production of 28.60 t ha^{-1} of dry biomass. The plantations of the *Miscantus* × *giganteus* genotype planted from the rhizomes appear more productive.
Biomass production Italian varieties of poplar (in kg dry weight of the individual) and converted to t ha^{-1}. $year^{-1}$ dry mass is listed in Table 1. Short rotation poplar of Italian provenance formed 51.47 t ha^{-1} of biomass in the first three-year cycle in 2012. In 2014, the second year of the three-year harvest cycle was average production of the biomass 34.40 t ha^{-1}. Based on an assessment of production above-ground organs monitored varieties of poplar are more productive plantations of Monviso and Pegaso varieties.

Table 1. Yield of dry above-ground biomass plantations of the energy plant species (t $ha^{-1}.year^{-1}$) grown in the research site in Kolíňany, southwestern Slovakia

Energy plants / Year	2010	2011	2012	2013	2014
Miscantus × giganteus	11.10	18.10	27.10	30.30	30.90
Miscanthus sinensis Tatai	10.80	16.90	22.60	24.10	26.30
Miscanthus - average	10.95	17.50	24.85	27.20	28.60
Populus MONVISO		28.80	58.33	21.92	19.86
Populus PEGASO		18.59	58.31	14.09	42.80
Populus AF-2		26.69	40.73	12.34	43.66
Populus SIRIO		30.11	48.53	15.51	31.60
Populus - average		26.05	51.47	15.97	34.48

Source: Own calculation.

Table 2. Single-factor analysis of variance (ANOVA) of the biomass yields between the Miscanthus genotypes and in each experimental year (2010-2014), between poplar varieties and experimental year (2011-2014) (level of significance is defined as: n: non-significant impact, +: significant impact in P ≤ 0.05, ++: P ≤ 0.01 and +++: P ≤ 0.001)

Analysed parameter	F	P-value	F critical	Significance
Miscanthus genotypes and Years	158,0191	9,28E^{-69}	1,947348	+++
poplar varieties and Years	10,71837	1,51E^{-08}	1,99199	+++

Differences in biomass production of the *Miscanthus* genotypes and Italian varieties of *Poplar* were statistically highly significant in each studied growing period (Table 2). It is also possible to note a high statistical significance (R^2 = 0.9923) between the growing years and the production of total above-ground biomass for energy grass *Miscanthus*.

Based on the evaluation of the ability of energy plants plantations, grasses genus *Miscanthus* and woody plant of the genus *Populus*, to produce sufficient above-ground biomass for energy use can be confirmed the high provisioning services of this type of agro-ecosystem. The subject of further ecosystem research will be the spectrum of other ecosystem services that these cultural ecosystems of energy plants do provide.

Collection of appropriate types of energy plants is supplemented by willow. [1] and [3] was devoted to the cultivation of willow plantation method. The results achieved in the Hungarian varieties Experess and Csala and Swedish variety Inger also confirmed the high adaptability of willows on the climatic conditions in the Slovak Republic, namely in the village Kolíňany (Nitra region). Ability to take roots and to allocate gradually biomass into individual organs is a prerequisite for a successful future production of organic mass. The results of authors do complement the information on the suitability of energy crops cultivation in Slovakia in relation to the possibility to use them for the benefit and ensuring the well-being of a man. Cyclic provision of woody biomass energy willow as poplar and miscanthus too is a basic ecosystem services that plantation of energy crops can provide.

Production parameters of varieties of willow and poplar compares [4] and authors confirm the results of research set out in this paper. Production parameters monitored varieties of willow and poplar in the Slovak Republic reached the level economically advantageous production. The research results contribute to the knowledge of the cultivation energy plants in Slovakia as alternative energy resources providing ecosystem services in the country. The production of these energy resources does not negatively impact on the environment quality. With proper use of natural resources may be used biota, support the natural biodiversity of the area and also ensure the protection of the nature and landscape.

CONCLUSIONS

Agricultural land in Slovakia, in terms of its division, is possible to use for alternative agricultural use, such as bioenergy. Secondary Agricultural land (696,038 hectares, which represents about 29%) and other land (368 587 ha, with about 15%) constitute a space that can be used also to other than the biological (food) production.

Plantations of energy crops in Slovakia represent a positive cultural ecosystem in agricultural landscape. They provide wide spectrum of ecosystem services. The main contribution of plantations of energy plants is their production potential - provisioning ecosystem services. The above-ground biomass production has potential use in bio energy as an alternative energy source.

The growth of energy plant *Miscanthus* (monitored in the period 2010-2014), in terms of biomass production (both genotypes), formed in the third growing year (2012) average yield 24.85 t ha^{-1}, which compared to 2011 increased by almost 60%. After the fifth growing period (2014) the growth reached average yield 28.60 t ha^{-1} of dry biomass. The plantations of the *Miscantus* × *giganteus* genotype planted from the rhizomes appear more productive.

Fast-growing poplars Italian provenance (Monviso, Pegaso, AF-2 and spreads) in the first three-year cycle in 2012 formed 51.47 t ha^{-1} of biomass. In 2014, the second year of the three-year harvest cycle was average yield 34.40 t ha^{-1}. Based on an assessment of production above-ground organs monitored varieties of poplar are more productive plantations of Monviso and Pegaso varieties.

The ability of energy plants plantations produce enough above-ground biomass for energy uses confirms the high provisioning services of this type of cultural ecosystem. The subject of further ecosystem research will be the whole spectrum of other ecosystem services that these cultural ecosystems of energy plants do provide.

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