NEW TECHNOLOGIES OF THE ENERGY PLANT PRODUCTION IN THE PREDICTED CLIMATE CHANGED CONDITIONS

MIECZYSLAW GRZESIK, *Dr hab.*
Research Institute of Pomology and Floriculture,
Poland ZDZISLAWA B. ROMANOWSKA-DUDA, *Dr hab.;*
KRZYSZTOF PIOTROWSKI, *M. Sc.*
University of Lodz, Poland

Introduction

Plant production for energetic purposes is becoming a center of interest of energy sector around the world. Energy produced from the plant biomass will soon reach 73% of overall renewable energy amount. Production of energy from plants puts to use local labour force, is environmentally friendly and does not increase CO_2 emission, especially in comparison with fossil fuels which during combustion release this gas bound into minerals millions years ago and send it to atmosphere. Cultivation of energy crops ensures also constant replenishment of plant supplies, has a positive influence on landscape, minimizes costs of ecosystem maintenance, ensures increase of autonomous energy supply, increase of farmers' income and positive influence on environment. Data from literature show that cost of energy production from grass as well as from straw is about three times lower than from hard coal or natural gas, six times lower than from oil and ten times lower than from propane. In Poland, recent demand for biomass is raising quickly and in 2020 the share of energy purchased or produced from renewable energy sources should be no less than 20% of total energy used.

Production of energy plants faces the several problems. More important problems connected with this type of production are selection of plant species, changes in natural environment, agrotechnology and competition to the food production. Recently area of fallow soils in European Community, which was increasing up to now, may start to diminish, and soils restored to cultivation will be used for production of food exported to quickly developing countries in Asia. Therefore soils left for energy biomass should be of low class, and there is abundance of those in some Europe regions more than 50% of total soil area falls within this category. Cultivation on soils of 5th and 6th class is quite hard in conditions of low fertility, rain deficiency and insufficient temperature differences [2, 3].

The information concerning renewable energy production in the predicted environment conditions is very scant in literature. Thus, the aim of this article is to present the new technologies performed by the authors, which focus on improvement of energy plant production on less fertile, weak and degraded soils and in climate change conditions.

Objects and methods of investigation

New methods of the energy plant cultivation in the predicted climate change conditions and on low quality soils should be environment friendly, allow increasing crop from 1 ha and increasing profitability of energy production. They include first of all: selection of plants species and economical analysis of energy crops profitability, agrotechnology, improvement of seeds quality and their conditioning, assessment of water and soil suitability for plant cultivation.

Results and discussion

Selection of energy plants species. Selection of energy plants species suitable for specific environmental conditions is very important in biomass production. It takes into account the production of large amount of dry biomass, resistance to stress, biodiversity of the area and phytoremediant features of the plants. Most of activities in the area of bioenergy production in several countries focus on gaining energy from willow *(Salix viminalis),* whose monoculture may in future disturb the balance of ecosystems and lead to environment degradation. At the same time global climatic changes may cause unpredictable problems connected with yielding, agrotechnology, plant disease and pest control, which may lead to reduction of gathered biomass and shake whole energy system. Widening biomass assortment with sunflower, Virginia mallow, switchgrass, corn, grasses and other plants producing huge amounts of dry mass may overcome these problems. Basing on assessment of growth in present and simulated conditions, in Poland some research are conducted on ecological methods of energy plant cultivation, depending on expected temperature changes, soil moisture content and application of ecological biostimulators [1, 3, 5-7, 9, 10].

In case of biomass production it is very important to select plant species that grow in different, highly variable climatic conditions. Due to global climatic changes there is demand for such energy plants which may be used in various weather conditions, which adapt to local environment easily and also can be used for phytoremediation. Energy plants suggested, i.e. willow, sunflower, Virginia mallow, switchgrass, corn and some species of grasses produce huge amounts of biomass, have positive influence on soil structure, prevent erosion, shape water conditions, absorb hazardous substances and fertilize soil. They are quite resistant to present unfavorable environmental conditions. Thus it is expected that they should grow well also in changing climate, high temperature, drought, and soil. The research performed by authors confirms these suggestions.

Selection of the plant species need also information concerning productivity of biomass dependently of CO_2 absorption and water needed for production of the biomass seer. In this respect, the grasses are very efficient because biomass some of them increase daily 30-60g $1m^{-2}$, while in case of other crops it is lower, 20-40g. At the same time they needs less water (150-350 g) for production of 1g biomass than cereals (300800 g).

Ecological technologies of the plant cultivation on low quality and degraded soils in aspects of climate change. Energy plant production needs new technologies of cultivation and adaptation of the methods presently used in agriculture to the insufficient environment conditions, including low quality and degraded soils in aspects of climate change. In these conditions the special attention has been paid to the crop rotation on particular area, species nearness based on allelopathy and plant protection, friendly to environment, against the pests or diseases.

Energy biomass production on the less fertile, weak and degraded soils should be fertilized with ecological and organic compounds containing nutrients. Our research [3, 9, 10] show that sewage sludge can be used in several energy plants on low quality soils. Addition of the sewage sludge (free of toxic solutions) to the used soils greatly increased and accelerated plant development which were exhibited by height of plants, their fresh and dry biomass, chlorophyll a+b content, net photosynthesis, membrane stability and activity of dehydrogenases, RNA-se and acid or alkaline phosphatase (Fig. 1). Additionally, the use of sewage sludge on large scale in the energy plant production dissolves the ecological problems of their storage and will lower the pollution of environment [8].

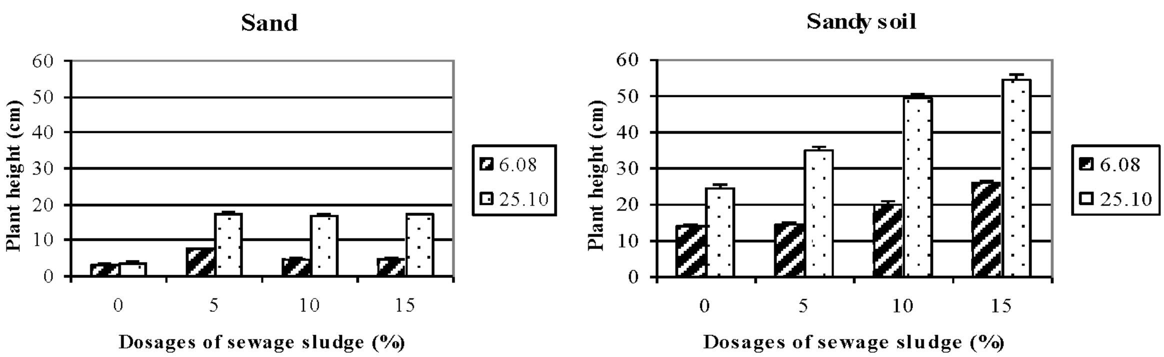


Fig. 1. Height of the Virginia fanpetals plants grown in the pots on sand and sandy soil mixed with 0-15% dosages of sewage sludge. Vertical bars denote ± SE

At present, a lot research is focused on improvements of the plant growth and development with biostimulators and effective microorganismes. Treatments with Asahi SL, Biojodis and water monocultures of *Cyanobacteria* increase the growth of plants under optimal temperature and soil moisture content and partly restore the harmful effect of stresses (caused by simulated climate changed conditions) on plant development and metabolic activity (Fig. 2).

Improvement of seeds quality by conditioning methods. Seed quality plays the crucial role in production of the energy plants, especially under insufficient conditions of the changed climate. Hydropriming, which is cheap and friendly to environment method, improved number, uniformity and dynamics of germination of several grass species grains and seeds of sunflower, corn and Virginia mallow, as well as emergence and growth of seedling. The used cell water suspensions of the several blue green algae species, selected from the fresh water pools in Poland and Czech Republic, affected seed germination, independently they were soaked for 24 hours or germinated on media moistened with them. These treatments greatly accelerated the root and hypocotyls development [4].

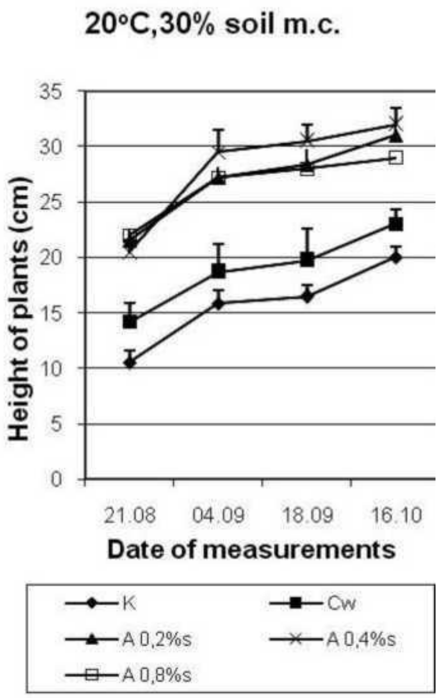
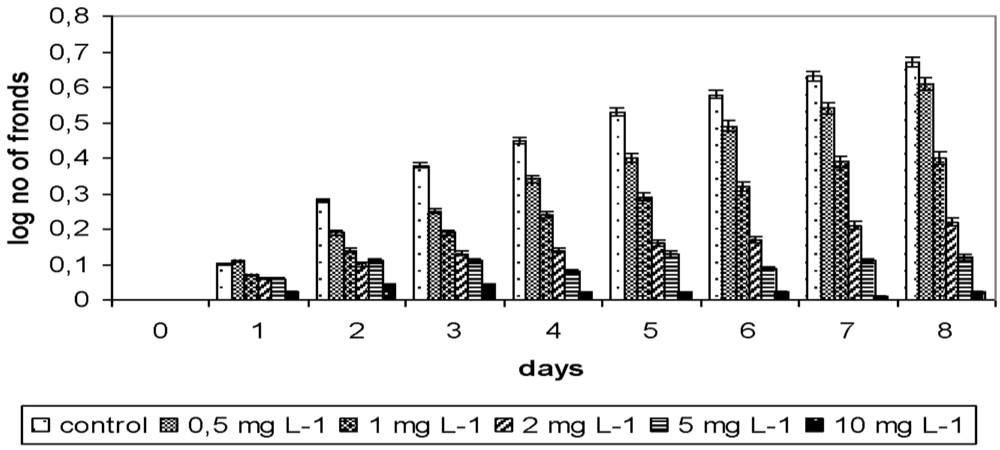


Fig. 2. Heigth of the Virginia fanpetals (*Sida hermaphrodita)* plants grown at 20^{o}C, 30% soil m.c.: not treated (K) or sprayed with Asahi SL (A 0.2-0.8%s) and watered with *Cyanobacteria* (Cw). Vertical bars denote ± SE

Assessment of water and soil suitability for energy plants cultivation with use of bioindicator methods. The quality of water or soil and the methods of its monitoring play the crucial role in energy plant production, especially when the water ecosystems are now being increasingly subjected to greater stress of anthropopression from various human activities. The physicochemical and biological characteristics quality of water depend on the location of the water reservoirs, type of sewage and the local human population in the surrounding area and their activities. As a result, large quantities of organic and inorganic materials are added to the aquatic ecosystem. Our research shows that the water and soil suitability for energy plants cultivation can be easily evaluated with use of bioindicator methods based on seeds sprouting and assessment of selected algae growth. The germinated seed of the selected species and water plants from family *Lemnaceae*, such as *Spirodela oligorrhiza*, can be used to evaluate water contamination with heavy metals and hepatotoxins. The mentioned methods can be successfully applied to look for markers which exhibit toxicity of heavy metals in water plants used for ecological energy plant production (Fig. 3) [11].



3. The effect of cadmium on the growth of *Spirodela oligorrhiza*. Vertical bars denote ± SE

The mentioned above new technologies are greatly helpful and necessary in energy plant production under insufficient environment conditions and in the predicted climate conditions. The research presented by authors show that the fertilization with sewage sludge (free of toxic compounds) and treatment with water monocultures of *Cyanobacteria* or with the selected ecological bioregulators or effective microorganisms, may greatly increase growth and biomass of several energy plants in different environment conditions. However, the dosages of sewage sludge or bioregulators and methods of their treatment depends on the plant species, soil quality, temperature, water amount and plant species [1, 3, 5-7, 9, 10]. The efficiency of the plant production in particular soil conditions and water quality can be easily predicted by using of the short timing bioindicator tests, based on the germinated seeds or the algae growth, instead of the expensive cultivation during the all vegetative season [8, 11].

Conclussion

Production of energy pants faces the several problems around the world, especially under the climate change conditions and on low quality soils. The presented new technologies based on the selection of plant species, fertilization with sewage sludge (free of toxic compounds) and treatment with water monocultures of *Cyanobacteria* or with the selected ecological bioregulators or effective microorganisms, may greatly increase growth and biomass of several energy plants under insufficient climate, soil and water conditions.

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