Industrial and Bioenergy Crops for Bioeconomy Development

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The production of industrial and bioenergy crops has been the subject of scientific research for many years; however, the implementation of previously proposed solutions for commercial production is still at an early stage. It should be emphasized that when developing the production of industrial and bioenergy crops on agricultural lands, it is important to avoid land-use competition with the production of food and feed. It is well justified, for initiating the sustainable production of industrial and bioenergy crops, to promote efficient species for growing on marginal lands, which are unsuitable or less suitable for food or feed production. Another possibility is restoring fallowed land for agricultural production, including the production of biomass for non-agricultural purposes.

Agricultural land abandonment is a process observed in most European countries. In Central and Eastern Europe, it was initiated with the political transformation of the 1990s. For example, in Poland, it concerns over 2 million ha of arable land. Such a large acreage constitutes a resource of land that can be directly restored to agricultural production or perform environmental functions. Therefore, a new concept for management of these lands is to produce biomass for bioeconomy purposes [1].

Industrial and bioenergy crops should include nonfood and nonfeed crops and generate agricultural products categorized as commodities and/or raw materials for industrial goods and bioenergy. Therefore, the research is mainly focused on the following groups of crops: SRC—short rotation coppice (willow, poplar, black locust, eucalyptus, etc.), grasses (miscanthus, giant reed, switchgrass, reed canary grass, etc.), herbaceous crops (Virginia mallow, Jerusalem artichoke, etc.), fiber crops (hemp, etc.), oil crops (camelina, crambe, castor, cardoon, etc.), and other alternative crops and their residues that are suitable for the industry or energy sectors. Research with some of the most common willow varieties in Europe has shown that it is possible to effectively use marginal land for the cultivation of willow intended for industrial purposes. However, it must be underlined that the key element that determines the production effects is the appropriate selection of varieties. Varieties with high production potential developed fewer shoots, but were taller and larger in diameter than other varieties [2]. Additionally, in another study, where 15 genotypes were grown at two different sites and harvested in two consecutive three-year harvest rotations, the very high impact of the genotype (81%) on the yield of willow was demonstrated. Therefore, the choice of a willow genotype is of key importance to success in willow production, since single-genotype monoculture on a commercial plantation may be a significant source of future problems with disease development or pest infestations [3].

It must be underlined that yields of Miscanthus × giganteus clones were also comparable, if not slightly better than other lignocellulose energy crops (poplar, willow, or Schavnat) in Czech conditions. Miscanthus × giganteus clones have good potential for commercial production of energy biomass, especially in warmer regions of Central and Eastern Europe with an annual sum of precipitation above 500–550 mm. The results show that the current economic conditions favor annual crops over Miscanthus (for energy biomass) and that this new crop shows very good adaptation to the effects of climate change. Selected clones of Miscanthus × giganteus reached high biomass yields despite very dry and warm periods and low-input agrotechnology, and they have good potential to become important biomass...
crops for future bioenergy and the bioeconomy [4]. Additionally, the cup plant (*Silphium perfoliatum*) is a new and promising bioenergy crop in Central Europe that can achieve high yields, especially on moist soils. However, spontaneous spread of this crop has already been documented, and especially valuable moist ecosystems could be at risk for becoming invaded by cup plant. Hence, fields for cultivating cup plant should be carefully chosen, and distances to such ecosystems should be held. If precautionary measures are observed, cup plant can take a place in the Central European agricultural landscape and make a valuable contribution to the conservation of biodiversity [5]. It was also shown that other perennial industrial crops did not cause a decline in wild biodiversity in comparison with unmanaged marginal land. Nevertheless, the cultivation of some crop species can cause a decrease in diversity of flora and fauna in the long term. For example, miscanthus and black locust cultivation were linked with a decrease in the number of plant species. On the other hand, the greatest biodiversity of plants and animals among crops was linked with the cultivation of willow; however, other crops also provided a good habitat for arthropods. No significant decrease in abundance of pollinators or natural enemies of pests were found in any perennial industrial crop [6].

These industrial and bioenergy crops can become an important source of biomass. Of course, the concept of their cultivation for nonfood (and/or nonfeed) uses is not new but, despite considerable investment in research and development, little progress has been made with regard to the introduction of such crops and their products into the market. For example, it is known that vegetable oil can surrogate petroleum products in many cases, as in cosmetics, biopolymers, or lubricants production. However, the cultivation of oil crops for the mere production of industrial oil would arouse concerns regarding competition for land use between food and non-food crops. Additionally, the economic sustainability is not always guaranteed, since the mechanical harvesting, in some cases, is still far from acceptable. The research underlines that the mechanical harvesting of sunflower, canola, and cardoon seeds is performed relying on specific devices that perform effectively with a minimum seed loss. Crambe and safflower seeds can be harvested through a combine harvester equipped with a header for cereals. On the other hand, camelina and castor crops still lack the reliable implementation of combine harvesters [7].

It must be underlined that the bio-based economy needs a sustainable supply of biomass for bioproduct generation and multiple uses. In this concept, no biomass should be used for energy generation unless the other options have been considered of using it to produce higher-value-added products. Noteworthy is that valuable substances in biomass are also used in the pharmaceutical, cosmetics, chemical, food, and feed industries. Hence, these substances should be extracted first, and after that production residues (post-production biomass) from the above industries should be used for production of biofertilizers, substrates, or bioenergy. Therefore, it is very important to analyze the possibility of obtaining bioactive compounds from lignocellulosic biomass before its transformation into biofuel. The research indicates varying contents of polyphenolic compounds in the biomass extracts of perennial herbaceous crops (*Helianthus salicifolius*, *Silphium perfoliatum*, *Helianthus tuberosus*, Miscanthus × giganteus, Miscanthus sacchariflorus, Miscanthus sinensis, and *Spartina pectinata*) depending on the harvest term in the growing period [8]. This information can enable the utilization of the studied biomass for not only the production of bioenergy but also to obtain valuable components of foodstuffs, medicines, and cosmetics. Additionally, another study suggested that supercritical extracts obtained from the aerial parts of *H. salicifolius* and *H. tuberosus* appeared to be a promising source of natural compounds with biocidal effect. They possessed antibacterial activity against Gram-positive and Gram-negative species, as well as antifungal activity against yeasts from the *Candida* genus. It is worth noting their antistaphylococcal activity. These extracts may be also regarded as natural potential antioxidants. The obtained data suggest that these extracts and their isolated bioactive compounds may be used as conservants in cosmetics and/or natural preservatives in food [9].
It is important to add that the research presented in this Special Issue “Innovations and Perspectives of Industrial and Bioenergy Crops for Bioeconomy Development” is the first small step towards identifying industrial and bioenergy crops that will be important for bioeconomy development. In total, 22 papers are published in this Special Issue, including three papers related to land availability, activities towards the development of the bioeconomy, and reparation of a former quarry area [1,10,11]. Among perennial industrial crops, three papers about Miscanthus [4,12,13], five papers about SRC (willow, eucalyptus, poplar, Siberian elm, black alder, white birch, boxelder maple, silver maple) [2,3,14–16], and two papers about cup plant [5,17] are reported. Studies on tobacco, oil crops, and agricultural residual biomass are also presented [7,18,19]. The next two papers describe the biodiversity of weeds and arthropods in different perennial industrial crops [5,20]. Finally, three papers on the topic of functional compounds and the content of other substances in perennial industrial crops biomass [8,9,21] and one paper about the growth potential of yellow mealworm reared on industrial residues [22] are reported. Of course, only a small excerpt is presented here from the point of view of: (i) the number and diversity of plant species; (ii) their productivity and biomass properties; (iii) their impact on broadly understood biodiversity and the environment; and (iv) the possibility of multi-directional and cascade use of their biomass. These issues will be expanded upon by further interdisciplinary research.

Conflicts of Interest: The authors declare no conflict of interest.

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