OPPORTUNITIES AND CHALLENGES OF AGRIPELLET PRODUCTION IN HUNGARY

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Abstract

Hungary could potentially utilize a large amount of its agricultural residues for energy purposes. Common feature of this by-products is that they are originally difficult to handle and they have a small bulk density. Pellet production is one possible way to utilization, however the high ash content and low ash melting point of these residues cause problems in pellet burner equipment. The annual volume of usable agricultural by-products was estimated by using GIS methods and statistical databases. Two agripellet plants in the country are currently being examined for energy use and feedstock. Pellets have also been produced from various by-products (wheat straw, rapeseed stem, sunflower husk) under laboratory conditions.

Keywords: *agri-pellet, agricultural residues, base material, energy balance*

INTRODUCTION

One of the possible uses of solid biomass residues within the biomass sector is a pellet production. The pellet is a high-pressure energy compact, cylindrical granulate. It is characterized by high density (600-850 kg / m3) and compactness [Szamosi, 2012]. Diameter of pellets is usually 5-10 mm, length 10-35 mm [Burján, 2010]. A common feature of agricultural by-products is that they have low bulk density, so making transport un-economical and firing is also problematic. The production of agripellet allows us to produce fuel that can be utilized in an automated way with good energy efficiency based on our previous studies [Papp – Marosvölgyi 2013]. Agripellet production is encouraged by that 79% of the 9.3 million hectares of Hungary are growing areas. This includes 5.3 million hectares of agricultural land and 1.9 million hectares of forest land. The amount of arable land area is currently only 2% less than in 2004, which indicates relative stability [KSH 2018]. The main raw materials used in agripellet production are straw and stem, but corn-cobs, mill by-products, pressed sunflower seeds can also be used. The most important crops for the utilization of by-products are corn, grains (wheat and barley), rapeseed and sunflower. The listed plants cover 80% of the arable land. Figure 1 illustrates the distribution of agricultural land by county based on Corine Land Cover data.

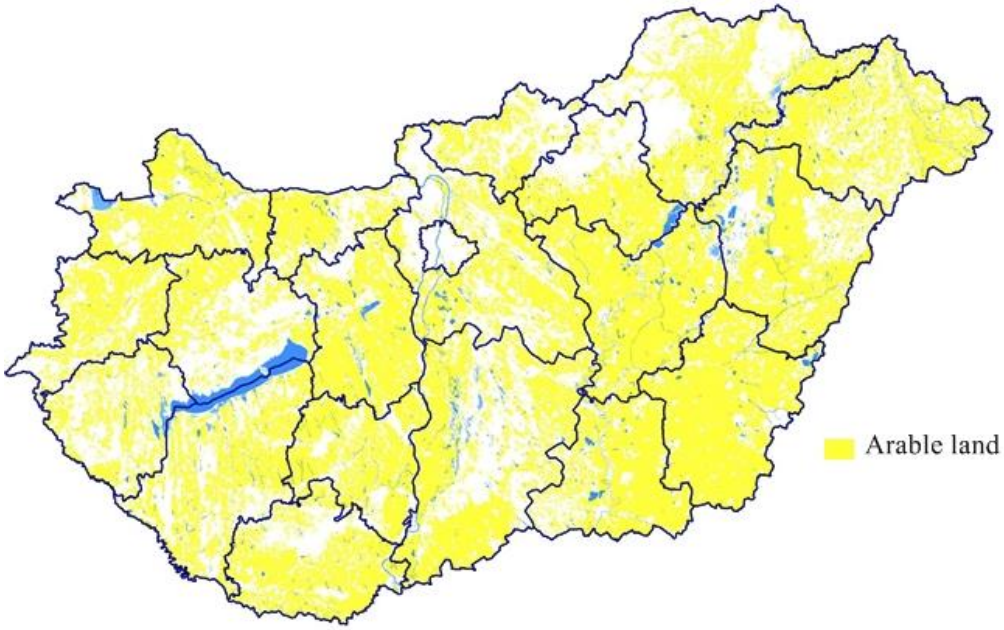

Figure 1. Agricultural areas in Hungary based on Corine Land Cover Map

The arable area of nearly 63% of the country's territory was 5 million 3 thousand hectares in 2018. Corn is produced on 1.1-1.2 million hectares annually in Hungary. In better years its production exceeds 8 million tons. The average yield of the last five years, taking into account the droughty years, is 6.1 tonnes per hectare on average[KSH 2018]. Compared to maize production, most of the residues (corn stove and cob) are left in field. Literature sources differ in terms of the amount of by-product produced per hectare between 0,8-1,5 seed:straw ratio. [Sokhansaj 2011, Boris 2011,Christian 2014, Pappné Vancsó 2010]. The most widespread use of corn stalk at present is plowing into the soil, which happens in approx. 90-93% of the cultivated area [Haszon Agrár 2010]. Large amounts of organic matter produce a cellulose effect in the soil that can be counterbalanced by nitrogen fertilizer [Tármeg J. 2008]. When the stem residues get into the soil, the carbon-nitrogen ratio changes drastically, which can lead to the pentosan effect. The essence of the pentosan effect is that the nitrogen needed to decompose high cellulosic organic substances is removed from the soil by the degrading microorganisms [Zsombik 2007]. The use of large amounts of nitrogen fertilizer significantly increase the cost and raises environmental problems. Therefore various literature values appear on the straw and stem quantities to be used for soil improvement, 20-30% of the weight of the stem would be optimal according to most analyzes. [EBTP 2013, Mann et al., 2002, Kline 2010] In order to obtain energy, a considerable amount of corn stalk is available, taking into account new technologies. However, the utilization as firing is made very difficult by the high 40-65% moisture content of the corn stalk. The material with lower moisture content is also optimal for pelletizing. The amount of energy spent on drying is often a problem during utilization. The calorific value of the stem is significantly influenced by the moisture content, which is highly dependent on the time of harvest and the weather conditions at harvest [Kocsis-Kelemen 2011].

Sunflower and rapeseed also represent a significant amount of agricultural by-products. Sunflowers grown 620 thousand hectares, rape on 330 thousand hectares in 2018. In the case of rapeseed, the production area increased significantly in last years [KSH 2018]. The amount of rape stem per hectare can be twice the weight of the crop. We have produced pellets of rapeseed stem and wheat straw mixture on an experimental pelletizer. In laboratory tests, we dealt with ash content and calorific value. Based on our previous studies, the rapeseed stem contains significant energy and has a calorific value of 14-16 MJ / kg at harvest [Papp-Marosvölgyi 2013]. Even though it has relatively low moisture content after harvesting, sunflower stems are commonly crushed and ploughed into the soil after harvest [Bai et al. 2002].

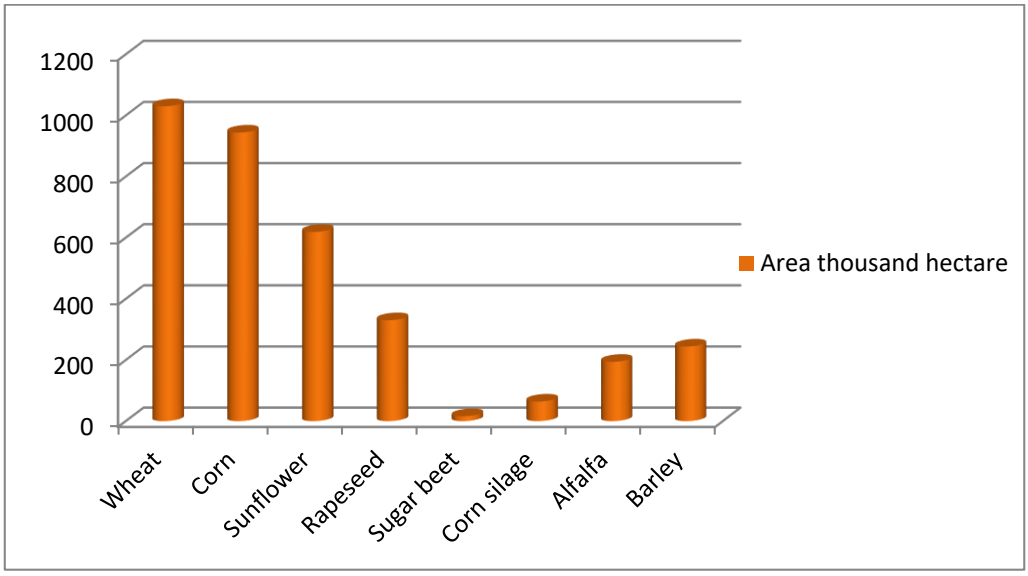

Figure 2. Production area of major plants

In the raw material base estimation, it is not only necessary to assess the amount of by-products generated in the area under investigation, but also the number of competing user plants that can reduce the amount of usable feedstock. The main areas of utilization of agricultural by-products are soil improvement, animal husbandry, power plants, heating plants, bale-fired boilers, paper industry and biogas plants.

MATERIAL AND METHOD

With the help of the Corine Land Cover map, the area of biomass was determined by land use categories. From 2012, the GIO-land project will take place under the Copernicus program. Its main tasks are to update the Corine surface cover database for 2012 (CLC, 2012) and to look for changes in surface cover between 2006 and 2012. As a new element, 5 so-called High Definition Surface Layers have been made for Europe. The CLC2012 databases were prepared with the EEA funding under the GIO Hungary project, which was completed in 2014 [FÖMI 2015].

Our work considers the following nomenclature from the standard EU CLC100. Artificial Surfaces: This group contains primarily land use classes. It details residential areas, industrial areas, transport infrastructure, mines, landfills and urban green areas. Agricultural Areas: Fields, pastures, closed gardens, vineyards and fruit plantations were sorted out of the category.

Yield averages and weight estimations for the agricultural plant by-products typical of the region were determined by processing Central Statistical Office tables and using literature data. The amount of by-product produced in agriculture is can be determined by the ratio of stem to seed [Boris et al. 2011]. In droughty years, yields and thus the amount of by-product can be significantly reduced. Therefore, the five-year average yield (2014-2018) was taken into account. Taking into account the generated residues and competing users, the annual average quantity of raw material that could be used for the production of agripellets in Hungary was determined. Two major agripellet plants are operated in the country. Data was collected from feedstock, quantity of pellets produced annually, area of feedstock transport, and energy utilization.

Due to crop rotation, five-year country area averages are taken into account when estimating the quantity of agricultural by-products. The main plants corn and wheat are most frequently grown in two-year cycles in the same area [Gyuricza 2006]. In the case of oil plants, three to five year cycles are observed. The amount of by-products, stalk formation may vary according to the different plant species. In Hungary, producers can choose from hundreds of varieties of corn and wheat. In case of the

autumn wheat, only 20-25 species, typically domestic varieties, are cultivated in 90% of the areas. In addition to the main products, agricultural by-products, straw and stem quantities, as well as plant breeding processes are undergoing a significant change in volume. The weight of wheat straw per hectare and sunflower stalk showed a declining trend over the past century, while in the case of corn stalk 1 ton increase can be detected. The reason is that the plant breeding activity has increased the stiffness of the stem.

An important part of the base material potential is the examination of competing users. One of the biggest users in the case of wheat straw is animal husbandry. The straws are mainly fed with ruminants, but only in small quantities. Due to their low energy concentration, hay cannot be replaced, so they can only be fed in small daily doses [Bokodi et al 2010]. The use of by-products as feed, in drought years, may be greater if the amount of harvested crop does not cover the need in animal husbandry. However, the amounts used for bedding are significant, although in recent years much less straw has been used due to new animal husbandry technologies. The amount of litter used (typically straw) depends on the technology used at the farm. Generally speaking, larger farms use non-littered or very low litter technology, swine farms use straw mainly for keeping sows [Maga J. 2012]. Based on literature data and statistical data on livestock in Hungary, the average annual amount of straw used for bedding has been determined. There has been growth in the cattle sector in recent years, the number of swines decreased slightly.

Of the 27 biogas plants in our country, only three or four of them use some plant stalks or straws as an additional raw material [AVE T.2013, Solti Biogáz. 2014, ELMIB 2010]. In the future, they are expected to increase, but the amount of available raw materials is not significantly reduced. The paper industry's need for straws in Hungary is only at Dunacell Ltd. 30 thousand tons per year [Koltai 2012]. Power plants and heating plants are increasingly using agricultural by-products, fruit trees and vineyards prunings. Bale firing in power plant is already based on agricultural by-products, primarily straw, in Pécs, using 240,000 tonnes of agricultural by-products per year [PannonP. 2016]. Recently, several attempts have been made at the Vértes Power Plant to burn corn stalks, which has proven to be successful with dry bales[Vértes Erőmű 2014]. At the Mátra Power Plant, significant amount annual 100,000 tonnes of straw, corn stalk and cob were also used [Mátrai Erőmű 2015].

The raw material requirement for pellet plants in the country has been determined by means of web-based data collection and personal contact. Despite the available base material, the annual amount of agripellet production is still a fraction of the amount of wood pellet. One reason for this is the increase in demand for high quality wood pellets in the European Union. Agripellets can be utilized in special firing equipment or in larger boilers and co-firing in power plants, because of high ash content of herbaceous plants, and due to lower ash melting temperature. These devices are expensive compared to a gas boiler, which may justify that agripellet has not spread to residential use.

The two examined agripellet plants produce an average of 1.1-1.4 tonnes of pellets per hour in similar capacity. The range of feedstock is varied, mostly wheat straw and sunflower husk, as well as mill by-products. Information was also collected on the supply and transport distance of raw materials. The hourly energy consumption should also be known for an estimated energy balance. Energy use depends on a number of factors, also due to technology, raw material or moisture content, on average between 160-175 kW/h in the examined pellet plants.

RESULTS

Results indicate a significant amount of agricultural by-products are generated annually. Annual residue production has been determined by taking the production area, yield averages and seed-stem ratio into account. Figure 3. displays the average results of 2014-2018.

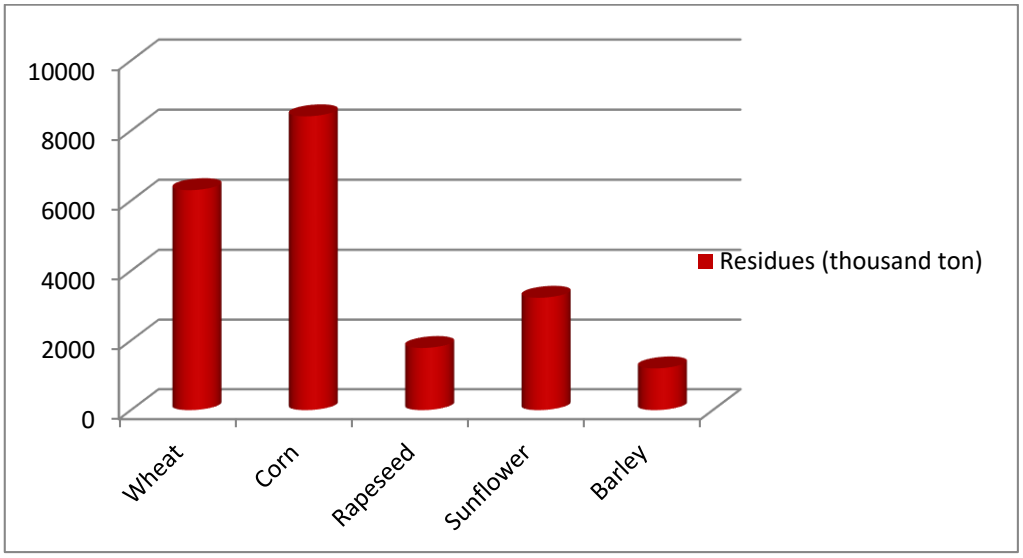

Figure 3. Annually generated residues in Hungary

Most by-products are derived from corn stalks and cubs. For the time being, collection takes place only in a small number of places, a significant amount could be used for energy purposes. The amount of wheat straw produced is also significant, but much of it is used in animal husbandry or is already being transferred to power plants. A large amount of sunflower stems are also produced annually, near 3 million tons, most of which are nowadays returned to the soil.

There is a large fluctuation in the annual volume of usable by-products. Drought and other extreme weather events in recent years can significantly reduce the amount of available residues. The supply area for raw materials also increases in a droughty year, which also has a significant impact on the energy balance of the process. The energy balance is determined by considering the average delivery distances and the hourly energy consumption during the production one tonne of pellets. EROI (Energy returned on energy invested) values also showed high fluctuations per raw material: 7-9 for wheat straw and 6-8 for rapeseed stem.

CONCLUSIONS

Despite the fact that there is a large amount of agricultural byproducts in Hungary, agripellet production only slowly develops. There are several reasons for this. The quality of the agri pellets is weaker than the wood pellets. It is often a problem with high ash content and low ash melting temperature. The operation of larger plants is also limited by the uncertain availability of raw materials in droughty years. The amount of basic materials is also significantly reduced by competing users. Therefore, mobile pellet makers and pellet harvesters which produced pellets in the field could play a greater role in the future.

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