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BIOMASS LOGISTICS IN THE FIELD OF RENEWABLE ENERGY

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Abstract The use of sugar beets is no longer limited to the production of sugar. The application of the beets as a substrate in biogas plants is a new domain that is gaining in importance. The biomass logistics for sugar beets from the field to the sugar factory, known as campaigns, has been greatly improved in the recent years. The harvest of beets for sugar production, usually by agricultural wage enterprises, is very powerful and the subsequent logistical steps are well coordinated. To improve the efficiency of the deployment of sugar beet for biogas production new logistics solutions are necessary.

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1. INTRODUCTION

The use of sugar beets as a substrate for biogas production is becoming increasingly important. Sugar beets have very high dry matter yields which can be achieved per hectare. The dry weight of the beets is mainly composed of carbohydrates and it is a large proportion of sugar in the form of mono- and disaccharides (Märlander et al., 2010). Sugar can be converted very rapidly and almost completely into biogas during fermentation. Therefore, this fruit can be used as a substrate for biogas plants very well.

The deployment of sugar beets for sugar production from the field to the factory is a very well structured and efficient logistics chain. Using the beets as a biogas substrate forms a new process with special requirements to technology and logistics. For the deployment of sugar beets for energy purposes some standard methods of the conventional deployment of sugar beets can be used (e.g. harvest, transport and loading operations). Other processes in the logistics chain of sugar beet for biogas production need to be optimized to increase the yield of drymatter an biogas (e.g. cleaning, de-stoning and storage procedures) (Schaffner et al., 2013).

The aim of this work is to show the deployment logistics of sugar for energy use and the approaches of optimization.

2. DEPLOYMENTS OF SUGAR BEETS

2.1. Harvest

In order to produce high methane yields in biogas plants large dry matter contents of the substrates are necessary. In relation to the sugar beet the requirements are a high-quality and low-loss harvest-, storage- and ensiling processes of the beets (KWS, 2009), and requires also technical process adjustments for the cultivation and use of sugar beet as an energy crop (Hoffmann & Starke 2011).

Injuries cause sugar losses during storage and should be as low as possible. During the harvesting process occur in particular losses due false beheading (to deep or to flat), root fractures as well as general beet injuries and the loss of whole beets. On way for a good quality of the harvest is the correct adjustment of special technical parameters like the driving speed, the machine settings and the speed of the cleaning rollers, thus ensuring high biomass yields. Another way to prevent damage to the beet plants as low as possible is the choice of the harvest process. The conventional variant is the beheading of the beets (Fig. 1)

Fig. 1 6-row beet harvester – method beheading (Source: KWS, 2014)

The sugar beets must be provided for sugar production without leaves. Beheading the beets is a good harvest method. However, the beet head means additional biomass and increases the potential methane yield in biogas production. Therefore, a different harvesting method must be chosen in order not to waste this potential increase in yield. By defoliating the plants the head can be harvested with the beet. Fig. 2 shows a beet harvester using the method of defoliating.

Fig. 2 Beet harvester – method defoliating (Source: RoPa, 2012)

Another advantage of this processing is that the beet during the harvesting process hardly occurs injuries. So substance losses are reduced and the storage stability is improved (Schaffner & von Felde, 2008). The determination of the beet distance, the peak height, the beet diameter and the leaf mass are relevant features for a high quality defoliation. This means a higher effort for the harvesting process. With the determination of these datas the leaf system can be completely removed at about 90% of the beets (Roller, 2010). Defoliation of the beets brings a yield increase about 3-8% (KWS, 2010a). In addition, the beet head contains essential nutrients that have a positive impact on the biological process in the biogas fermenter (Neumann, 2009). By a specific fertilizer strategy another yield increase of about 5-8% can be achieved (KWS, 2010a).

2.2. Transport

The transport and transloading operations of sugar beets for sugar production and energy production are identical. After grubbing the beets are usually stored in ricks at the field (Fig. 3).

Fig. 3 Storing sugar beets in ricks at the field (Source: i.m.a. 2010)

This steamlines the other logistical steps and has additionally the great advantage that adhering soil dries and the beets will be partially cleaned in the subsequent loading processes e.g. with the beet cleaner loader (Fig. 4). So a large part of sand and soil remains on the field (Schaffner et al., 2013).

Fig. 4 Loading of sugar beets using beet cleaner loader (Source: Südzucker AG, 2012)

Depending on soil type and soil tare it is possible to load about 100 – 200 tons of beets per hour. In the further transport planning, the bulk density of sugar beet should be considered. This has a great influence on the utilization of the volume of carrier vehicles for further transport. A cover of beet clamps with heavy fleece is usually used for protection against weathering (Schaffner et al., 2013).

2.3. Storage

The precondition for the continuing use of sugar beet in the production of biogas is a suitable storage. Basically various methods of preservation and storage are available:

- Cold storage,
- Storage in ricks,
- Ensiling.

The process of cold storage is technically and energetically connected with high costs and therefore not suitable for the use in the process of biogas production. A long-term storage of sugar beet in ricks is depending from the weather possible until February or March. Experiences shows that a storage in ricks is associated with high energy losses and therefore not suitable for the biogas production (Schaffner & von Felde, 2008). The ensiling biomass is a preservation method, which is used in agriculture. Aim of ensiling is to enable biomass through the use of micro-organisms in a state that allows longer storage. So the valuable ingredients are substantially preserved. For sugar beet following ensiling processes are possible:

- Mixed silage (ensiling of chopped beets with other feedstuffs such as corn),
- Storage of whole beets in fortified bunker silos,
- Storage of whole beets in hoses,
- Storage of chopped ensiled sugar beets in elevated tanks,
- Storage of chopped ensiled sugar beets in lagoons.

A frequently used method for ensiling sugar beets is the mixed silage with suitable mixing partners such as Corn. The positive effect of corn is that the silage effluent of the sugar beet is collected. The disadvantage of this method is that due to the time-staggered harvest dates of maize (mid-September) and sugar beet (mid-October), the earnings potential of the last stored fruit can not be fully exploited.

It is also possible to store whole sugar beets in fortified bunker silos. It is a big effort to collect the resulting silage effluent and to control the covering of the bunker silo over the entire ensiling process (Neumann, 2012). The crushing of the beets is done after ensiling, immediately prior to the entry into the fermenter and requires additional technology in the biogas process. (KWS, 2010b).

Storage of whole or chopped beet in hoses provides another method of preservation. Crushed beets produced a lot of silage effluent and have large losses due to the residual respiration of the biomass (Weissbach, 2009). The storage of whole beets in hoses requires also much firmed surface, which is relatively expensive (Heilmann, 2012). The liquid preservation of sugar beets in tower silos (steel fermenters) and in lagoons (Fig. 5) offers new possibilities to use beets throughout the year.

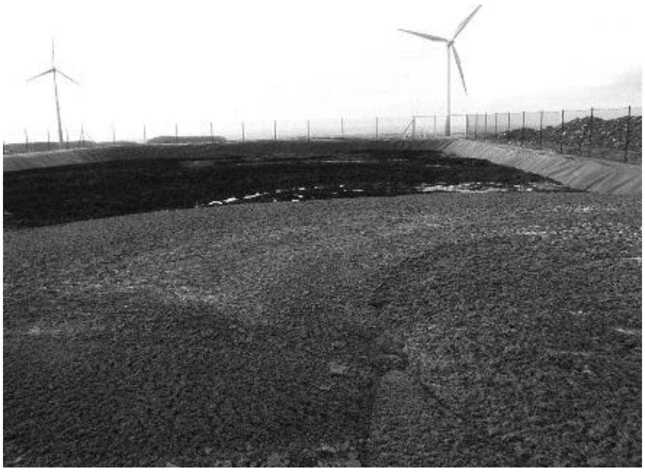

Fig. 5 Storage of sugar beets in lagoons (Source: Zuckerrübenjournal, 3/2010)

For this method, the beets should be cleaned of stones and sand, and then crushed. The ensiled sugar beets are characterized by a good pumpability and homogeneity of the substrate. Thereby the substrate is easy to handle in the biogas process. The supply of ensiled sugar beets in the biogas fermenter can be automated furthermore. These aspects provide great advantages of ensiling chopped sugar beets compared to the other storage options (Neumann, 2010).

3. CONCLUSION

The deployment logistics of sugar beet for sugar production is not transferable to the process of using beets in biogas plants. In general, the sugar beet logistics for processing into sugar is very well developed in relation to harvesting, transportation and storage. For biogas production a high dry matter content and thus the biomass is important. In particular, the harvest and storage processes need to be optimized. Instead of the beheading the sugar beets they are defoliated, to increase the biomass yield. The conventional cold storage can not be used for storage of the beets for economical reasons. For this, the biomass can be ensiled, to make them storable. The storage of sugar beet silage in lagoons is increasingly establishing itself as the biomass is very easy to handle in this form in the biogas process. Currently there is a large potential for optimizing the deployment of beets for biogas production.

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BIOGRAPHICAL NOTES

Sebastian Dettmann – Master of Science at the University of Rostock, Department of Animal Production and Process Engineering. Master thesis defended at the University of Rostock in Germany. His research Author of 14 scientific papers published in national and international journals. He researches the use of sugar beets in the biogas-production (logistics, use of additives, parameters of the biogas-process, enlargement of the surface for micro-organisms), the use of Paludicultures on fen sites for material and energy purposes (concepts of technology based on parameters of soil, logistics concepts, storage, activated carbon, conditioning of biomass) and deals with e-learning modules for bioenergy.

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