The sugar beet: new uses as a energy crop

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History

In 1747, the German chemist A. S. Marggraf (1709-1782) announced his discovery of sugar in fodder beets (*B. v.* ssp. *v.* convar. *vulgaris* var. *crassa*). His student Franz K. Achard (1753-1821) devised in 1801 an economical industrial method to extract the sugar in its pure form. At the same time the sugar beet was developed through selection of beets with higher sugar content. The sugar content was increased from 8% to 18 - 20% today.

Taxonomy

The beet (*Beta vulgaris*) is a plant in the *Chenopodiaceae* family. It is best known in its numerous cultivated varieties. Two subspecies are typically recognised. All cultivated varieties fall into the subspecies *Beta vulgaris* subsp. *vulgaris,* while *Beta vulgaris* subsp. *maritima*, commonly known as the sea beet, is the wild ancestor of these, and is found throughout the Mediterranean, the Atlantic coast of Europe, the Near East and India.

Group *B. v.* ssp. *vulgaris* convar. *vulgaris* (roots beets) contains all beets grown for their thickened root rather than their leaves.

Economic importance

Sugar and energy

Today sugar beet is grown on approximately 5 million ha worldwide, it provides 30% of the world sugar production. In the last five years sugar beet was detected as a source for biofuel production: today in the EU 27 more than 110.000 ha are planted especially for the bioethanol industry, mainly in France and Germany.

Biogas

In the last 10 years in Germany a decentralised network of biogasplants was installed. Today about 6.800 plants with an installed capacity of >2.6 MW are producing biogas, which is either converted in electricity or directly (after the removal of CO_2) fed into the existing gas grid. Biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, plant material and energy crops. This type of biogas comprises primarily methane (60%) and carbon dioxide.

In Germany 600.000 ha (3% of arable land) is used for the production of energy crops, mainly silage maize. In Germany a premium for the produced electricity is granted only, if you plant crops only for the purpose of energy production. The forecasted further increase of the maize area started some political discussion in Germany, whether it is desirable to increase the acreage planted with biogas maize. A lot of owners and operators of biogas plants are also looking for other energy crops in order to spread the risk.

Lately, sugar beet is also used in biogas plants. The biggest advantage of sugar beet is its high content of the disaccharid saccharose, which ferments very fast in the biogas plant.

This table shows the advantages and disadvantages of different crops in regard to possibles use in biogas plants (table 1.).

Proceedings. 46th Croatian and 6th International Symposium on Agriculture. Opatija. Croatia (38-40)

Table 1. Advantages and disadvantages of different crops in regard to possibles use in biogas plants

Energy crop (entire plant)	Mass formation potential	Energy output of entire plant	Conversion time an efficiency	Cost in whole fermentation process
Maize	+++	++	-+	+
Sorghum bicolor	+++	++	-+	+
Silaged cereals	+	++	+	+
Sugar beet	+++	+++	++++	++

(Source: own research, KWS 2008)

The biggest advantage of sugar beet is its optimal use of installed m^3 of biogas plants which is very intensive capital.

The main problem with sugar beet is the storage in order to secure the supply of biogas plants all around the year. Several systems like mixed silages (maize and beets in layers), whole beets ensilaged in vacuum plastic tubes or mashed beets in open lagoons are tested successfully. Removal of stones and clay is done satisfactorily with beet washers or beet mashers.

It is estimated, that in the EU 27 in five years up to 100.000 ha will be planted with sugarbeets to be used solely for biogas production.

After the beets have been proofen to be a good substrate for fermenters of biogas plants, the question came up, whether the classical sugar beets are the right choice for this purpose.

Breeding of bioenergy beets

Some five years ago the beet breeding departement of KWS decided to start a breeding programme in order to breed beets especially designed for the use as a fermantation substrate in biogas plants. In the classical sugar beet breeding the quality of the juice is very important and thus a limiting factor. But in the fermenter of a biogas plant the beet quality is of no importance. The most important goal is the maximum production of dry matter/ha (table 2.).

Table 2. Comparison of breeding goal sugar beet and energy beet

Sugar beet	Energy beet
Breeding parameters	Breeding parameters
- White sugar yield	- Dry matter yield
- Sugar content	- Dry matter content
- Standard losses to molasses	- Methane and biogas yield
- Root yield	- Soil tare
Use	Use
- Sugar production	- Exclusively for the production of biogas
- Ethanol production	
- Industrial beet	
- (Biogas)	

Using different genetic resources from the *B. v.* ssp. *vulgaris* convar. *vulgaris* (root beet) family energy beets were developed and tested in official trials. Already in the first generation the energy beets could produce 1.4 t/ha or 6.5% more dry matter yield / ha than a sugar beet variety (figure 1.). They also showed a great advantage if compared to a fodder beet.

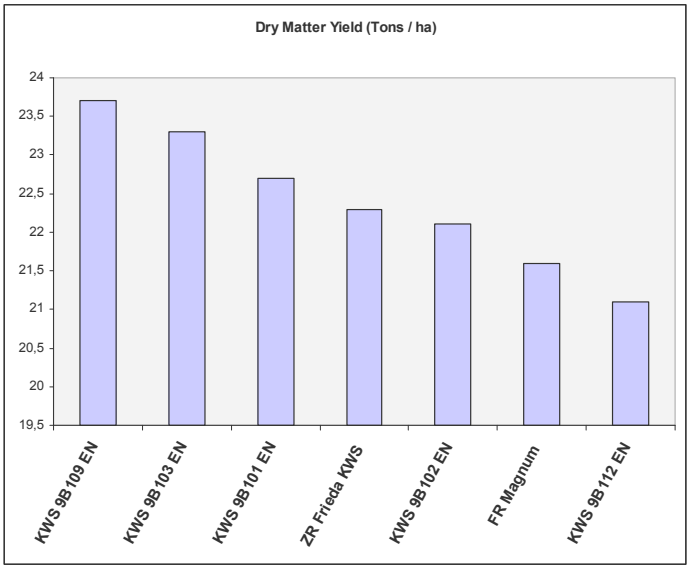

Figure 1.
Dry matter yield (t/ha) of sugar beet variety

Conclusions

The production of renewable energy in the world, based on biomass, will become more important in the future. Considering the needs to produce food and energy crops on a limited worldwide acreage, crops with a high output/ha will be more in the focus in the future. Sugar beet has already proven its suitibility for the bioethanl industry and the last years it became even more important for the biogas production. Consequently, KWS has set up a breeding programme especially for energy beets which already showed the first generation of energy beets with a great yield increase regarding dry matter content compared to classical sugar beet.

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