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"From the seed to fermenter"

A short guide to growing beet for biogas

Factors for success

Cultivating beet for biogas

Seed quality

- Soil preparation
- Drilling
- Pelleting/seed protection
- Shoot emergence

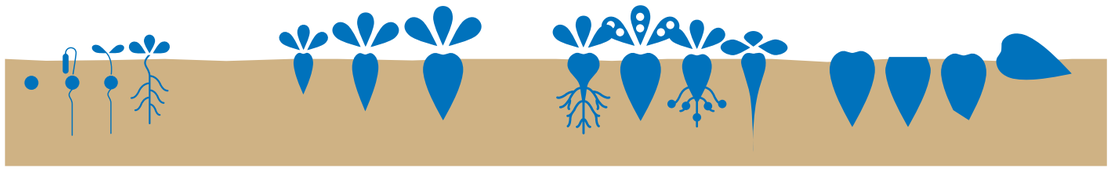
Standing crop quality

- Stand density
- Early development
- Foliage
- Nutrient supply
- Interactions

- Leaf health
- Rhizomania
- Nematodes
- Rhizoctonia
- Drought tolerance

Lifting quality

- Harvesting schedule
- Crown height
- Crowning/defoliation
- Breakage losses
- Soil tare
- Stones



Drilling and soil **Growth** **Harvest**

Sugar beet is gaining increasing interest as a substrate for biogas plants. Sugar beet has valuable characteristics for the fermenter and for the fermentation process but also for crop rotation. This makes it a good supplement to maize as the main substrate.

The key factors for success in beet production ensure a higher dry matter yield and methane yield per hectare. Beet for biogas is cultivated in fundamentally the same way as beet for sugar production. However, reducing molasses-producing substances does not play any part in biogas production.

For success with Biogas beets:

- ✓ Aim for high dry matter yields
- ✓ Select varieties that are easy to lift with little soil tare
- ✓ Use fertiliser with a higher N content
- ✓ Harvest with the crown intact

Soil preparation

For fast, even growth

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The aim of soil preparation for sugar beet is to produce a seedbed of finely aggregated soil, to achieve a deep soil which is easily penetrated by roots with no hard pan and to protect against erosion. Around 50 percent of sugar beet is cultivated in a mulch drilling process. Working using as few steps as possible increases the profitability of beet cultivation and has a positive effect on soil life and soil stability.

1. Soil protection

Growing catch crops, reducing tillage and using mulch drilling protect the soil against capping and against erosion by wind and water. It takes around two months from drilling before the beet canopy completely covers the soil. During this time, the top layer of soil is exposed to erosion by heavy rain or wind scour.

2. Catch crops

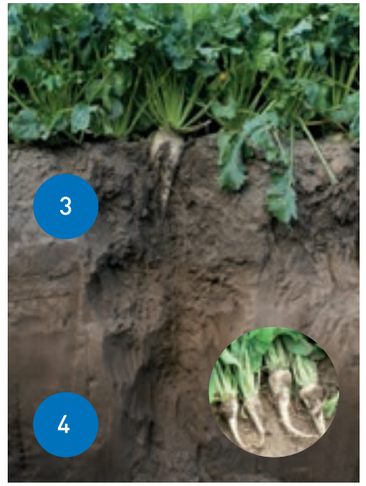
Catch crops are the basis of the mulch drilling or serve to reduce nematodes. Nematode-reducing mustard and oil radish are the primary catch crops used for this.

3. Aggregate stability

All soil-specific treatment measures should aim for a high soil aggregate stability with an optimum pore volume. This facilitates root penetration, water retention, air supply and nutrient availability for the beet.

4. Soil depth

Sugar beet roots reach up to 2.50 metres deep. In dry periods, the roots of the beet grow towards the water in deeper soil layers. In this way, beet can cope with drought stress more easily than other crop types. They have a lower water requirement than other field crops, needing 200 litres of water to produce 1 kg of dry matter (transpiration ratio). Sugar beet plants react to soil compaction with curved roots and by forming side roots.



Drilling

Seedbed and sowing date

Drill as early as possible

The sooner sugar beet can be sown, the longer its vegetation period will be. Experiments over many years have shown that crops drilled from the middle of March to the middle of April produce the highest sugar yields. Every day that sowing is delayed will reduce the yield. From the end of April these yield losses are doubled. However, early sowing dates bring a higher risk of night frost. Temperatures of -2 to -3 °C can cause irreversible damage to the seedling in the sensitive "hook" phase when the apical hook of the seedling is emerging from the soil surface.

Seedbed

The sensitive beet seedling makes high demands on seedbed preparation. The seed pellet is deposited on a consolidated seed level 2 - 3 cm deep. This ensures good contact with the water rising by capillary action from the subsoil. A layer of aggregated soil is laid loosely on top so that heat, oxygen and rainfall can reach the pellet and seedling. The aim is to achieve as rapid and as homogeneous emergence as possible.

Irreparable damage occurs from seedbed preparation with a high soil moisture content, particularly when sowing. Structural damage can then be observed which is shown by unequal development of beets in the stand.

Direct drilling of sugar beet.

Seed requires good contact with soil.

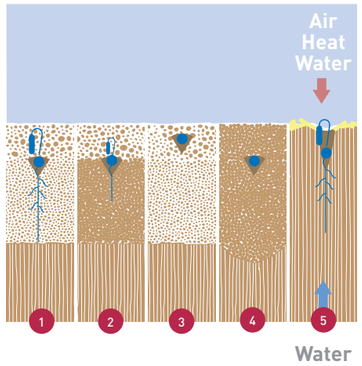


Diagram: Seedbed for sugar beet

1. Optimal seedbed under practical conditions
2. Too wet seedbed preparation
3. Too shallow deposition
4. Deposited in tractor tracks
5. Direct/mulch seeding without seed bed preparation

Stand density

Emergence and seed quality

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The stand density has a significant influence on sugar beet yield. This is determined by row spacing, seed spacing and shoot emergence

Obtaining homogeneous stands

Many years of experiments have shown that the highest sugar yield is achieved with a stand density of 96,000 plants per hectare. Therefore beet stands of 92,000 to 100,000 plants per hectare should be aimed for. Currently, as a national average for Germany, around 1 unit of sugar beet seed is sown per hectare. With a row spacing of 45 cm and seed spacing of 22 cm, this results in 100,000 seed placements. Thus, with an emergence of 90%, a stand density of 90,000 plants per hectare is achieved.

Highly regular stand densities produce homogeneous stands with uniform plants. This is the basis for a beet harvest with the least interruption and the lowest losses through consistent beet size and crown height.

Seed pellet

Sugar beet seeds are pelleted with the fungicides Thiram and Tachigaren as standard to protect the germinating plant. The level of insecticide protection can generally be selected as required, but the choice of a modern neonicotinoid will offer protection against aphids and beet fly until the beet leaves meet across the rows.

Row spacing 45cm:				
Seed spacing in cm	16	18	20	22
seed quantity U/ha	1.39	1.24	1.11	1.01
90% shoot emergence	125	112	100	91
80%	111	99	89	81
70%	97	87	78	71
60%	83	74	67	61
50%	70	62	56	51

Row spacing 50cm:				
Seed spacing in cm	16	18	20	22
seed quantity U/ha	1.25	1.11	1.00	0.91
90% shoot emergence	113	100	90	82
80%	100	89	80	73
70%	88	78	70	64
60%	75	67	60	55
50%	63	56	50	46

Plants per hectare (in thousands) according to row spacing, seed spacing, seed quantity and shoot emergence.

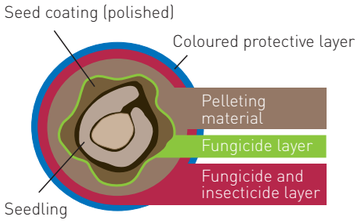

Diagram: Seed pellet

Nutrient supply

Achieving a balance

The optimum supply of nutrients to the plant is essential for a high sugar yield per hectare. Economic and ecological considerations need to be taken into account if this is to be achieved.

Setting nitrogen levels

Nitrogen fertiliser plays a prominent role in nutrient supply. In general, beet yield increases with an increase in nitrogen fertiliser, however at the same time the sugar content decreases, so there is an optimum point for the sugar yield. Years of experiments have shown that the optimum for sugar production is a nominal value (Nmin soil reserve + fertiliser) of 160 kg N/ha. The nitrogen fertiliser can be slightly increased when growing for biogas. Molasses-producing substances increase with raised fertiliser levels; however these are not a concern when producing biogas from beet. The soil nitrogen level is determined with the aid of the Nmin or EUF soil examination.

Mineral nitrogen fertilisation should be carried out in a split dressing – first after drilling, followed by a second application at the 6-8 leaf stage. During the first weeks, the plant only extracts small amounts of mineral N from the soil. It is only when the top growth really begins that the uptake increases. During the vegetation period, sugar beet also uses the nitrogen liberated from the organic substance of the soil.

Soil dressing after cereal harvest

Soil dressing should be calculated bearing in mind crop rotation and be matched to the yield expectation for the location. Optimal supply of main nutrients is equally important as the application of micronutrients in the case of a deficiency.

Beet is a boron-loving plant. Deficiency can be seen as heart rot and dry rot.

Determining the need for soil dressing after the grain harvest

Expected sugar beet yield	P_2O_5	K_2O	MgO	N
	Nutrient supply level C			Nominal=Nmin+N fertiliser
	kg/ha	kg/ha	kg/ha	kg/ha
				Normal resupply
40-50 t/ha	40-60	140-180	30-50	160-180
				High resupply
50-70 t/ha	60-80	180-220	50-70	140-160

Fertiliser requirement taking into account the nutrient exploitation on soils of differing yield potentials (crop residues remain on the field)

Early Development

Rapid leaf growth

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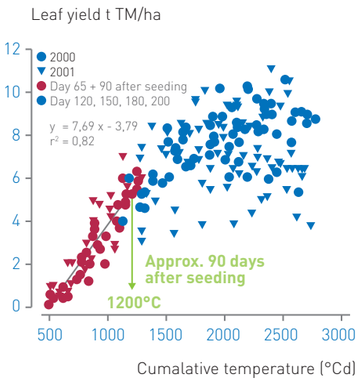
A full canopy as quickly as possible

For sugar beet, early development has a significant influence on sugar yield.

Early leaf development better exploits the sun's energy, leading to a higher yield. The weather Is a major influence: high spring temperatures encourage early leaf development until the beet leaves meet across the rows.

However, soil preparation, drilling dates, emergence and stand density can all have a beneficial effect on leaf development. Getting these right ensures that young plants have uninterrupted growth until the leaves meet across the rows.

Interactions between the individual agricultural measures can further improve the development of the young plant and it's leaves.



Relationship between cumulative temperature and sugar beet leaf dry matter in eleven locations in the years 2000 and 2001 modified according to Kenter and Hoffmann 2002

Infobox:

Producing high dry matter yields per unit area is crucial for biogas production. For sugar beet, the dry matter yield results from the beet yield and the dry matter content. The important aspects for producing biogas from beets are:

- Dry matter content (DM) %
- Beet yield (BY) t/ha
- Dry matter yield (DMY) t/ha
- Methane yield Nm^3/ha
- Soil tare

Investigations by the Institute for Sugar Beet Research (IfZ) in Germany have shown that there is a very close correlation between dry matter yield and sugar yield. It was possible to derive a formula with the aid of which the dry matter yield could be calculated. The expected methane yield results from the dry matter yield.

The particular benefit of sugar beet lies in its fermentation characteristics: it provides gas fast. The carbohydrates in the beet are present as sucrose in a form which can be transformed very easily. While maize silage requires around 90 days for complete fermentation, beet substrate needs less than 15 days.

Additionally, beet substrate is excellent as it can be stirred conveniently.

Leaf diseases

Keeping leaves healthy

Monitoring standing crops

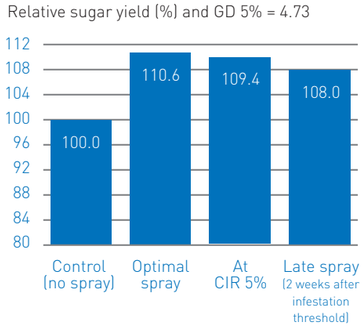
Over the course of the vegetation period, the foliage should be kept healthy so that the photosynthesis efficiency is not reduced by a smaller leaf area. The most important leaf diseases are Powdery mildew (1), Ramularia (2) and Rust (3). Severe infection of leaf diseases can cause yield losses of up to 50%. Mixed infections often occur and can still be spreading in the standing crop in late autumn.

Standing crops of sugar beet must be monitored for leaf spots every week from the beginning of June to the end of September. Warnings posted on the internet give information about current disease incidence. The actual infestation is strongly dependent on the microclimate and its extent can vary widely from place to place.

The "leaf pluck method" has been established for monitoring the crop. Treatment is carried out after reaching an infestation threshold of 5% CIR (crop infestation rate). A leaf is plucked from the central leaf area of 100 beets selected at random from the stand. If spots are found on 5 leaves, the infestation threshold of 5% has been reached.

The use of fungicides has been proven to be very beneficial, even in years of light disease incidence.

One or two sprays (July and possibly September) will keep the canopy strong and building yield, while also helping to prevent root rots.



Influence of different application times on reported sugar yield in Söllingen 2009 – 2011 (initial infestation with Cercospora, later mixed infection with mildew)

Selecting a variety

Exploiting the full yield potential

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Sugar beet is the best biogas beet

Varietal testing by the Institute for Sugar Beet Research in Germany has shown that sugar beet produces higher dry matter yields than fodder beet. Beet bred for sugar has also been shown to be superior to the new, specially bred 'energy beet'.

There is a close correlation between high sugar content and high dry matter content. Varieties with a high sugar content and high biomass yields produce the best dry matter yields.

Varieties with a genetically fixed low soil tare and which are easy to lift are the best choices. These are varieties with a less distinct root groove, smoother surface and a narrow beet body.

Exploiting the full yield potential with resistances

Disease and parasite infestations can cause losses of yield, in particular if the infestation cannot be controlled by plant protection measures. Resistant varieties ensure the yield and the natural yield potential of the location can be exploited.

BARENTS, a Rhizomania tolerant variety from Strube, has been identified in Danish National Bioenergy beet trials as being a consistent first-class performer with all the right characteristics for beet for biogas – high DM yields of roots and tops, good sugar content, excellent root shape and easy to harvest. Strube seed quality ensures

Strube's very high seed quality ensures a good stand and a good harvest

Harvest time

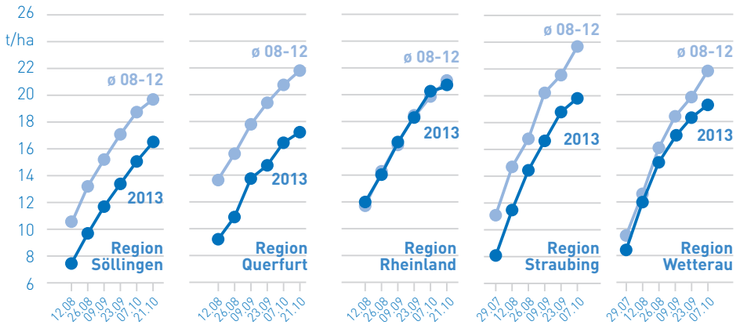
September to April

Sugar beet has a large harvest window. In most years, with the UK's kinder maritime climate, beet can be harvested fresh and processed from mid-September to April. The limiting factor for the beet harvest is largely down to when it is possible to drive across the field in the autumn and winter. If the risk of freezing is considered too great, the beet can be lifted and stored.

After the harvest, beet can either be stored in well-constructed clamps or can be pulped or shredded and stored well in lagoons or silos. It is also possible to incorporate beet into mixed silage in the clamp.

Beet provides very high dry matter yields

In our test harvests in five typical agricultural regions, the dry matter yields at the end of October in the last five years ranged from 18 to 26 tons per hectare. With an "open" autumn, sugar beet can put on an additional 30% of its yield by the end of the year



Graph: Development of the dry matter yields according to test harvests with a 14-day interval from 5 typical agricultural regions

For the future: "Winter beets": beet sown in early autumn can have an extended vegetation time and the dry matter yield is further increased. The fresh beet substrate stays available over an even longer period. Recently the "bolting control" genes were identified. Cool temperatures cause vernalisation which triggers shoots and the development of the flowering stem in sugar beets. Breeding can now be targeted to develop wholly bolting-resistant beets. These would continue growth after the winter to form high-yield beet roots.

Lifting quality

Harvesting the final crop

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Checking harvested beet

In order to produce a high biomass per hectare, there must be as little loss as possible during lifting. The greatest source of losses is the harvester: according to German surveys, lifting losses may be up to 20 percent in the most unfavourable cases. Harvested beet should therefore be checked regularly.

Beet with crown cuts that are too deep or are skewed cost as much yield as root breakage losses. The quality of the harvest can, to a large extent, be influenced by the harvester setting and the speed and quality of driving. Homogeneous standing crops, with equally-sized beets and consistent crown heights, increase the lifting quality.

Factors which cannot be influenced result from the soil type and soil surface which affect the growth of the beet. Difficult weather conditions at harvest time also have a negative effect on the quality of the beet harvest

Defoliating not crowning

The molasses-forming substances which reduce the sugar yield should be ignored when producing beet for biogas. This means that the beet should be defoliated rather than crowned; resulting yields can be up to 10% higher.

1 Checking lifting quality
2. Crowned beets – for the fermenter, up to 10% of the grown yield is lost
3. Defoliated beets

Diagram, left: possible harvesting losses

Your partner

Expert in biogas

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If you are considering growing beet for biogas, we are here to help

Strube is one of the world's leading sugar beet breeders supplying seed of more than 170 varieties of sugar beet to more than 35 countries around the world. Our long-standing reputation for innovation, is backed by a strong and continual investment in research and development into all aspects of beet growing.

Our international base is in Germany, where more than 7000 on-farm biogas plants are operating successfully. We have worked closely with researchers, manufacturers and growers to develop beet varieties best suited to producing biogas and build a bank of knowledge about growing the best beet crop.

Strube can advise growers, agronomists and biogas plant operators, particularly on selecting varieties and cultivation methods.

You will find our latest global experience at www.strube-sugarbeet.co.uk together with news about demonstrations and events that we will be attending.

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Seed of Strube sugar beet varieties will be available through selected partners with a proven track record of supplying a range of energy crops and good customer support.