# Effects of crop management on yield and winter hardiness of bolting winter beets cultivated for anaerobic digestion

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## Introduction

Planting of sugar beet in summer or autumn and overwintering the crop in the field (winter beet) may contribute to nearly perfect utilization of the site specific growth factors radiation and water, especially in early spring. This may result in a high yielding crop which can (1) be harvested early in the growing season (May) and (2) provide a substrate favourable for anaerobic digestion. A basic prerequisite for such a winter beet cropping system is a high winter hardiness under German climatic conditions. Field trials were conducted to investigate the influence of crop management (sowing date, plant density) on yield and winter hardiness of bolting winter beets.

## Methodology

*Experimental design*

- Split plot design with 4 replicates
- 2 Sites: Göttingen, Lower Saxony, continental climate and Kiel, Schleswig-Holstein, maritime climate

*Experimental factors*

- Main plot: Sowing date (SD) April, June and August
- Sub plot: Plant density (PD) [thousand plants ha$^{-1}$] 103, 148, 246 (SD: April, June); 148, 246, 370 (SD: August)

*Measurements*

- Intermediate harvests (Nov, April, June)
- Total fresh and dry matter yield of leaves and beet
- Classification of maximum beet diameter
- Temperature during winter (above canopy, at soil surface, 5 cm in soil, in beet crown)

## Results and Discussion

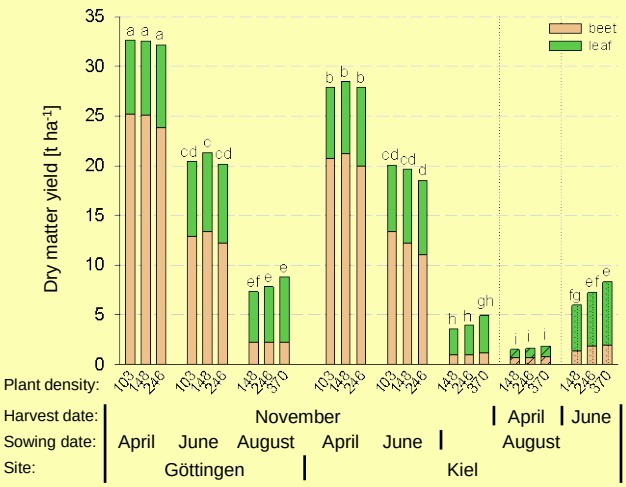


**Figure 1** Influence of site, sowing date and plant density (in thousand plants ha$^{-1}$) on dry matter yield of sugar beet in November 2009 (solid bar), April (dashed bar) and June (dotted bar) 2010. Different letters indicate significant differences at $p \leq 0.05$ (Tukey test).

- Later sowing significantly decreased total dry matter yield before winter while plant density had almost no effect on yield [Fig. 1]
- Overwintering completely failed at Göttingen [Fig. 2 A] due to bare frost in December 2009 decreasing beet crown temperature to -5°C [Fig. 3]
- At Kiel
  - substantial plant losses occurred in March 2010 due to low temperatures combined with the lack of a protective snow cover [Fig. 3]
  - only August-sown sugar beets survived the winter
  - Survival rate increased with decreasing mean maximum beet diameter [Tab. 1]

| Plant density [thousand plants ha$^{-1}$] | SR [%] (sd) | MMBD [cm] April | MMBD [cm] June |
|---|---|---|---|
| 148 | 77 (15.7) | 3.3 | 4.6 |
| 246 | 85 (6.6) | 2.8 | 4.0 |
| 370 | 90 (6.6) | 2.5 | 3.5 |

**Table 1** Survival rate (SR) and mean maximum beet diameter (MMBD) in April and June of **August**-sown sugar beets grown at **Kiel**.

**Figure 2** June-sown sugar beets grown at Göttingen (A) and Kiel (B) in January 2010. Plant density: 246 thousand plants ha$^{-1}$. Frost damage is indicated by glassy dark colored tissue (A).

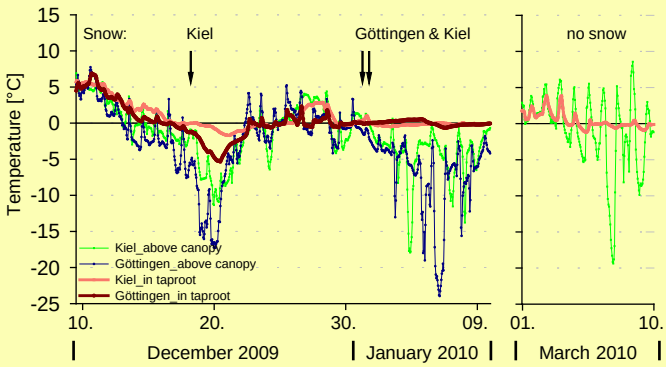


**Figure 3** Temperature above canopy and in the beet crown of June-sown sugar beets grown at Göttingen (Lower Saxony, Germany) and Kiel (Schleswig-Holstein, Germany). Plant density: 246 thousand plants ha$^{-1}$.

## Conclusions

Sugar beet has a high yield potential which can be completely utilized only if the crop is sown early. Overwintering in the field is risky but doesn't seem to be impossible. The success of overwintering is highly dependent on the local weather conditions (min. temperature, snow cover) as well as morphological beet parameters (max. beet diameter). A solid snow cover positively influences the frost tolerance of sugar beets. August-sown sugar beets with less beet diameter seem to be more frost tolerant than sugar beets sown earlier (April, June).