PRODUCTION OF METHANE FROM SUGAR BEET

**Introduction**

The objective of this study is to evaluate if sugar beets could be promisingly introduced as alternative energy crop into the biogas supply chain, in terms both of methane yield and general impact on Italian actual agro-energetic sector. In fact, due to its high organic dry matter content per hectare, sugar beet theoretically has a great potential for the production of biogas. Moreover, the possibility to feed anaerobic digesters with different biomass, as co-digested material or as an alternative to corn silage, could represent an advantage also for agriculture sector, improving both crop rotation sustainability and land use efficiency.

**Materials and methods**

The project consisted of four phases:

- **Phase 1**: Evaluation of potential biomass yield using four different sugar beet varieties: 1 - sugar beets with high yield (type E); 2 - sugar beets with a high sugar content (type Z); 3 - two different fodder beets. The trials were carried out along two years (2009-2010) in two different locations of the Po river valley, depending on water availability: high-iron moraine (Miranda) and low-iron moraine (Casarea).
- **Phase 2**: Evaluation of silage storage capacity with silobag for 210 days (November-June). The sugar beets were divided in 2 portions: leaves/roots (L&T) and roots. Two theses were used: a shredding mixture of whole plants (30% L&T and 70% roots) and only roots.
- **Phase 3**: Evaluation of biogas yields in a batch digester (60 days of hydraulic retention time-HRT at 39°C). Fermentations of T0 (fresh biomass after harvest), T60 (ensiled biomass after 60 days) and T210 (ensiled biomass after 210 days) were carried out for each thesis (2 replicates). The first, mixing 80% of T210 with 20% of cattle manure (A) and the second (B), mixing 50% of T210 with 20% of cattle manure and 30% of corn ensilage (Table 2). Both tests was conducted for 70 days, that is the time necessary to conclude two cycles.

**Evaluations potential biomass yield**

As shown in [Figure 1](#), the best biomass yield was reached by the Type E bolts in Cordovia and Casemarate (30.7 and 19.7 t/ha of dry matter, respectively). Whereas, fodder beets showed a higher fresh biomass yield (> of 160 t/ha), but with a lower content of dry matter and volatile solids than Type E and Z. Even though all varieties had a volatile solids content higher than 90%, calculated on dry matter, the best quality characteristics were achieved by Type E (VS > 96% and DM = 21%).

**Silage storage**

Biomass was generally well preserved up to the 210th day. Weight loss of only roots thesis was primarily due to leachate production. It was nearly 10% after 60 days of storage, and 23% after 210 days of storage (Figure 2). Organic nitrogen losses were almost around 90% after 60 days of storage, while dry matter losses was, on average, around 7%. After 210 days all samples showed a little effect of concentration. The same trend was observed for volatile solids (VS).

**Batch fermentations**

The highest production of biogas (817 Nm³/VS) was reached by T0 fresh roots samples. Stark and Hoffmann obtained 760 Nm³/VS of biogas after 25 days of digestion. With ensiled samples (T60 and T210), biogas yield fell by 27% (642 Nm³/VS) and 32% (616 Nm³/VS) respectively. Concerning to whole beets thesis, biogas yields were not significantly influenced by time of storage. Average methane content of biogas was in the range 64-65.5%.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sample description</th>
<th>Type material</th>
<th>Dry matter (%)</th>
<th>Volatile Solids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Only Roots</td>
<td>Fresh</td>
<td>18.3</td>
<td>95.32</td>
</tr>
<tr>
<td>2</td>
<td>Slage 60 days</td>
<td>Fresh</td>
<td>17.1</td>
<td>94.33</td>
</tr>
<tr>
<td>3</td>
<td>Slage 210 days</td>
<td>Fresh</td>
<td>17.6</td>
<td>93.88</td>
</tr>
<tr>
<td>4</td>
<td>Whole beets</td>
<td>Fresh</td>
<td>17.3</td>
<td>94.88</td>
</tr>
<tr>
<td>5</td>
<td>Slage 60 days</td>
<td>Fresh</td>
<td>17.2</td>
<td>93.33</td>
</tr>
</tbody>
</table>

Table 1. Sample characterization utilized in Batch trials.

**Continuous fermentations**

Biogas yields were 718±87 Nm³/VS and 649±60 Nm³/VS for thesis A and B respectively, with a methane content of 63±2%. In thesis B, biogas production has fallen.

**Biogas Yield per Hectare**

Methane yields varied from 6,052 to 10,896 Nm³/ha for roots and from 929 to 1,749 Nm³/ha for L&I. L&I contributes to methane production up to 15%.

**CONCLUSIVE REMARKS**

Sugar beets has shown good yields in terms both of dry matter and methane. Type E reached the best yield as dry matter (19.7–30.7 t/ha). Only roots samples achieved 790 Nm³/VS of biogas, with 63% of methane. The storage practices were well-conducted, but a process optimization could be obtained by the recovery of leachate. Biogas yield was between 7,081 and 12,645 hm³/ha for roots and L&I.

**REFERENCES**


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G. CIUFFREDA, S. LUNghi, M. SILVIAN, “Utilization of leaves and tops of sugar beet in the biogas production”, 72nd IEA Congress, Copenhagen, 2010