Production of Sulphur from biogas applied as fertilizer in Agriculture

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Speaker: ir. Leo Habets
l.habets@paques.nl
Bacterial conversions in the anaerobic digestion

SO$_4^{2-}$ → Sulphate reducing bacteria → H$_2$S

sulphate → sulphide
Average Biogas composition

Methane CH$_4$ 70 – 85%
Carbon dioxide CO$_2$ 15 – 30%
Hydrogen Sulphide H$_2$S 0.5 – 2%
Bacterial conversion in the Thiopaq process

$\text{H}_2\text{S}$
sulphide

Thiobacillus

$(\text{O}_2)$

$s^0$
Elementary Sulphur
Thiopaq: bioconversion of $\text{H}_2\text{S}$ into Sulphur

“Alkaline washing with washing liquid recovery”
Rhombic Bio-Sulphur particles as seen via microscope

Optical microscope 1000 x

Electron microscope 3000 x
Bio-Sulphur allows better growth

Shortage of chlorophyll means:

- Less capture of sun light
- Less growth
- Less yield!
You can see it when looking over a field.
Growth stimulant for rape seed research at University of Alberta Canada shows 23 to 40% more yield.

Breton Canola rape seed yield in kg/ha using different type of Sulphur fertilizer.

<table>
<thead>
<tr>
<th>Fertilizer Type</th>
<th>Yield (kg/ha)</th>
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<tbody>
<tr>
<td>No Sulphur</td>
<td>1590</td>
</tr>
<tr>
<td>K2SO4</td>
<td>1740</td>
</tr>
<tr>
<td>S-Commercial 1</td>
<td>1710</td>
</tr>
<tr>
<td>S-Commercial 2</td>
<td>1800</td>
</tr>
<tr>
<td>Claus Sulphur</td>
<td>2230</td>
</tr>
<tr>
<td>Fertipaq Sulphur</td>
<td>1460</td>
</tr>
</tbody>
</table>
Inhibition of apple scab germs tested at PPO Fruit

Germination of scab spores on agar plates, at different dosage Fertipaq Bio-Sulphur

Treatment

- Untreated
- Fertipaq (0.01%)
- Fertipaq (0.1%)
- Fertipaq (1%)
- Fertipaq (10%)
Dosage-effect ratio for mildew on cucumber
Tested at PPO Fruit

Dosage-effect ratio of Fertipaq Bio-Sulphur and one other Sulphur product for mildew on cucumber

Meeldauw index

Dosage (g/l)
Rain fastness of Bio-Sulphur
Tested at PPO Fruit

Residue of Fertipaq Bio-Sulphur on the leaves during rainfall

- Amount of sulphur on the leaves (g/m²)
- Rainfall (mm)

![Graph showing the relation between rainfall and amount of sulphur on leaves.](image-url)
Summary of test results

- Bio-Sulphur has very good properties as fertilizer
- It shows very high rain fastness on leaves
- Is very effective against fungi spores such as from apple scab and mildew
- In total less dosing is needed compared to established products
Since fuel is all desulphurized the world Sulphur production has become huge

Production

90%
10%

Oil & Gas
Mining

World: >80 million ton/y

Use

Acid Production and others
Agriculture

35
45

(China import: 10 million ton/y but demand 60 million ton/y)

(Bio-Sulphur 30,000 ton → 50,000 ton/y)

The use in agriculture is significant!
Why?

- Modern intensive agriculture needs more S
- Flue gas desulphurization leads to shortage in the soil
- S is important for N uptake by plant (synergy)
- S becomes more important for crop protection

(Prices for S are low and depend on application and package size)
Visible difference between hydrophylic and hydrophobic
How did Fertipaq become alive?

• Paques has the desire to give a new and sustainable live to the residues of its installations

• The use of Bio-Sulphur for business generation had won 2nd prize in Paques Innovation Award in 2010

• Marketing study was done resulting in Business plan.

• Fertipaq has been established to recover Sulphur but also nutrients and minerals in order to market them for sustainable use
Questions to be solved beforehand

1. In which form to supply the Sulphur to the market?
2. How to collect and transport (Logistics)?
3. Who will be our customers; farmers; distributors?
4. Do we need a permit for fertilizer application?
5. Do we want/need fungicide registration?
6. How to organize the business structure?
7. Can we integrate the activities in the existing Paques departments?
Mineral industry? (THIOPAQ customers)

FERTIPAQ BV (FERTIPAQ Shanghai Trading Ltd)

Fertilizer producers

Suspension concentrate

Distributors

Farmers

Blenders

Cake; flakes; powder

flakes

Business model
Packages of SC for large and small customers

- 800 litres IBC
- 75 x 10 litres
- 10 litres
- 300 ml
- 100 ml
Amount of raw material to be processed is still a challenge!
Conclusions

• A sustainable solution for our gas scrubber residue has been realized.

• Bio-Sulphur has advantages over established Sulphur products

• Bio-Sulphur SC can be applied in organic farming.

• Business has grown to break-even.

• New destinations of Bio-Sulphur such as for metal precipitation are under investigation.
Thanks for your attention!