Combined organic cereal and biogas production:
plant physiology, emission of the green house gas N_2O and environmental aspects of bio-gas production

Several theses related to an on going field experiment. Offers for PV, MINA and Agroecology masters, 30 or 60 ECTS

Supervisors IPM: Marina Azzaroli Bleken (organic farming, plant physiology, nitrogen in plant and soil) , Peter Dörsch (nitrous oxide), Trine A. Sogn (bioenergy), expertises from bioforsk.

Background: The use of chemical nitrogen fertilizer is forbidden in organic farms. The necessary nitrogen for protein formation and plant growth and must be obtained from biological nitrogen fixation. In cereal farms this can be easily done by introducing a green-manure (a grass-leguminous mixture) in the crop rotation. Nitrogen fixed in the roots of the leguminous by symbiotic bacteria will, after decomposition, provide the necessary nitrogen for the following cereal crop. If the farm has animals the grass-leguminous mixture is harvested and used as valuable forage.
In cereal farms without animals a year with green- manure represents a loss of income. Furthermore, nutrients are leached during the winter from the non-harvested green-manure, with the double consequence of reducing the fertilizing effect and polluting the environment. An alternative is to harvest the green-manure and use it for biogas (methane) production. Biogas is from an energetic point of few the most efficient bio-fuel. The production resembles the processes that occur in the digestive track of ruminants when they consume cellulose. In addition to producing methane, the process leaves a sludge similar to animal manure. This is rich in nitrogen and organic carbon, and can be used to fertilize other crops. At present there is no practical experience about how to manage cereal in combination with biogas production, and whether this is a way to go for reducing nitrogen pollution and overall emission of green house gases to the environment.

Field experiments
A joint Bioforsk and IPM project (Byggro) is looking for the opportunities and drawbacks of combined cereal and biogas production on organic farms. Green-manure has been established summer 2008 on four field experiments, which include a control cultivated with cereals only. Several green manure managements will be tried in 2009, with and without harvesting of the foliage for bio-gas production. Sludge from bio-gas will applied in the spring 2010, and effects of the alternative green-manure managements will be tested on the cereal growth, yield and quality. In addition there will be laboratory studies on the rate of decomposition of the sludge added to the soil, and (at IPM only) measurements of N_2Oemissions.

Thesis
There is scope for cooperation between students working on different thesis.
1) Effects of nitrogen availability on plant growth (best for PV and Agroecology)
This is an applied growth physiology work, studying in depth the relationship between nitrogen nutrition, leaf area index and radiation use efficiency, which determine the photosynthetic ability of the plant. Based on the field experiment described plus additional trials during the summer. Available both in 2009 and 2010.
Supevisor: Marina Azzaroli Bleken

Conventionally fertilized barley. Leaves are dark green and wide=> good light interception	Border between the field experiments, with a grass-clover mixture	Barley grown on a long-term organically managed soil, undersown with green-manure. Leaves are light-green (little chlorophyll) and narrow

To the rightt is a detail of one of the Byggro experiments in Central Norway: compare it with the normally fertilized crop on the leftt. Differences are mainly due to lower N availability Photo: A.K. Bakken.

2) Mineralization of sludge and plant residues (PV, MINA, Agroecology)
The focus is on the decomposition of organic matter during the winter, that is when temperature is close to zero. Decomposition releases the organic nitrogen as NH_4^+ which is further transformed to NO_3^-. Sludge and plant residues are added to soil samples in small jars and kept at a range of temperature from -2 to 12 or 15 °C. Net nitrogen mineralization rate will be estimated at several intervals over a total period of 120 days, and respiration will be measured based on evolution of CO_2. Available in 2009 and 2010, can be run outside the growing season, depending on the needs of Bioforsk. A separate study can be dedicated to the effect of freezing/thawing on the short time decomposition of fresh green-manure: this can be run in the late summer/early autumn of 2009.

Supervisor: Marina Azzaroli Bleken , researcher at Bioforsk, with support from involved researcher at Bioforsk, Peter Dörsch and Lars Bakken

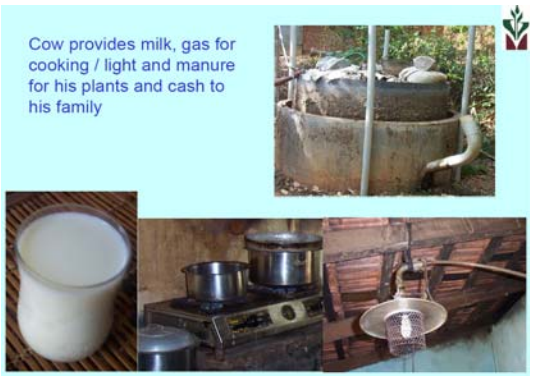
Methods for sampling gas from an incubation trial, for example CO_2 from respiration
Photo M.A. Bleken

3) **Nitrous oxide emissions** (best for MINA)
Nitrous oxide is emitted during reduction of NO_3^- to N_2, which is part of an alternative respiration process of many bacteria when oxygen is lacking. In the soil, conditions often switch back and for from aerobic to anaerobic, as for example during long lasting rainy weather in the autumn, or during thawing in the spring. Under these changing conditions reduction is not complete and N_2O is released to the atmosphere. The presence of nitrate and of easily degradable organic matter, for example foliage of green-manure or sludge enhances N_2O emission. Small chambers are used to capture the effect of green-manure management on N_2O emissions at nearly weekly intervals during the whole year. Available in 2009 and 2010.

Supervisor Peter Dørsch and Marina Azzaroli Bleken

Sampling of N_2O gas from a previous experiment. Photo: P. Dörsch

4) **Life cycle assessment of biogas–production** (MINA, Agroecology, PV)
The alternative managements of the field experiments are thought applied in a real farm situation. Will energy from the locally produced biogas compensate for the energy used to produce it? Will there be any benefit in terms of GHG emissions per unit of edible energy in the cereal grain? Students may consider comparisons with conventionally produced cereals, or with an organic farm where the foliage of the green manure is fed to animals and the animal manure + farm sewage is used to produce methane.



Supervisor Marina Azzaroli Bleken, Trine A. Sogn and external expertises

This slide is from the presentation "A successful organic farmer with a one-cow dairy" by A.K. Moorthy, 2005, regarding the real case of an Indian farmer

NB: The project does not study the biogas fermentation as such. The project considers the production of the plant substrate and the utilisation of the sludge, and their agronomical and environmental consequences.

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