Strategic management of nitrogen within an organic cropping system using digestate from biogas production of recirculated crop residues

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Implications
This project investigates strategic management of nitrogen by integrating crop residue management with biogas production. The approach offers potential for diversified farmer income, as food crops, feedstock for biogas and digestate for nutrient cycling are produced simultaneously. This type of diversification provides multifunctional solutions in organic farming, especially in production without access to animal manure. Biogas production from crop residues offers the possibility of reducing both emissions and leaching of nutrients to the surrounding ecosystems, as compared to the case where crop residue is incorporated into the soil for decomposition (Baggs *et* al. 2000; Velthof *et* al. 2002). This type of multifunctional cropping system provides solutions that can also help to solve issues on conventional farms, such as N emissions, and can also provide local production of biogas.

Background & objectives
The main objective is to determine the effects of strategic field application of a biogas digestate on crop yield, crop quality, and methane potential, based on anaerobic digestion of crop residues, catch crop and ley from the cropping system. Our hypothesis is that anaerobic digestion of residues and recycling of the digestate will lead to an improved N use efficiency compared to incorporating the residues untreated in to the soil. This strategy addresses four important aspects of food production: sustainable land use, timely and efficient cycling of nutrients, reduction of N losses and self-sufficiency in renewable energy.

There is a need to optimize the sustainable use of agricultural land in consideration of future food supplies, as well as climate change mitigation and adaption due to an increasing level of competition for land used for food or energy production (Harvey & Pilgrim, 2011). By designing multifunctional cropping systems, it is possible to both produce high-quality food crops and biogas in the same cropping season.

There is also a need for economically feasible supplies of plant nutrients in organic systems without animal production to increase both yields and quality. Mineralisation of N has to be synchronized with crop growth and N acquisition, in order to decrease the risk for emissions of nitrous oxide and ammonia, as well as reduce leaching of nitrate to the ground water and streams (Doltra *et* al. 2011). Biogas digestate has a great potential for solving these issues by supplying the crops with N when they are in an intensive growth phase with large needs.

Key results & discussion
The three crops that gave the highest yield of residual biomass were pea intercropped with barley, lentil intercropped with oat, and barley in pure stand. The dry weight is tightly linked to the energy exchange for methane production. Calculations with theoretical estimates based on the dry weight show that the crop residues, ley and catch crops from the crop rotation can produce approximately 800 m^3 methane/ha. A medium sized organic farm in Sweden of 90 ha with a similar crop rotation, could thus potentially produce 7200 m^3 of methane/year, equivalent to 72 000 kWh, in addition to food products.

Three main results will be presented at the conference:

1) Dry matter production and nitrogen content in each crop residue, ley and catch crop.
2) Nitrogen content of the digestate from the whole cropping system.
3) The actual methane production from the crop rotation.

How work was carried out?

This research project runs from 2012 to 2015. The cropping system was established in 2012 to determine effects of strategic nutrient management, including a treatment involving anaerobic digestion of crop residues and a grass mixture as the feedstock. The crops were chosen to yield food products that are attractive for the Scandinavian market and in addition allow for an additional production of biomass, see table 1. Additionally, all fields were re-sown after harvest of the main crop with an autumn or winter-growing crop, to reduce nitrogen leakage during the winter season (Catt *et* al. 1998). All crops were fertilised with external biogas digestate during the initial year. In the coming years, we will study the effects of three nutrient management systems on the yield, N-uptake, crop quality, energy balance and economy. The management methods are based on:

1) Leaving the biomass resources *in situ* in the field.
2) Moving the biomass resources to nitrogen-demanding crops.
3) Collecting the biomass resources for anaerobic digestion and using the resulting digestate for the nitrogen demanding crops.

References

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Table 1. Crops in rotation

No in sequence	Main crop	Catch crop/winter crop
1	Ley	Ley
2	White cabbage	Buckwheat and oil radish
3	Lentil (90%) and oat (10%) undersown with ryegrass, white and red clover	Ryegrass, white and red clover
4	Beetroot	Winter rye
5	Winter rye	Buckwheat and lacyfacelia
6	Pea (80%) and malt barley (20%) undersown with ley	Ley