5 |MAY 2024

Experiments on Organic Fertilizers from Biogas Plants

In cultivation trials in the north, the properties of organic fertilizers from biogas plants and other digestate products are being compared to mineral fertilizers. We are investigating whether it is possible to grow spring wheat using different digestate products as fertilizer. The field trials in Umeå, Västerbotten, are part of the Boost Nordic Biogas project, where participants from northern Sweden, Finland, and Norway collaborate to develop biogas production in the region. In the cultivation, pelleted biofertilizer from Alviksgården, recycled ammonium sulfate, and liquid biofertilizer from Härnösand have been used as nitrogen fertilizers. Biochar from sewage sludge and dewatered biofertilizer have been used as phosphorus fertilizers. These types of fertilizers have in turn been compared to both mineral-fertilized and unfertilized controls.

About Our Cultivation Trials

In our cultivation trials, we are investigating new fertilizers with the aim of reducing emissions and offering more local alternatives on the market. We are working to promote regional circular options over imported mineral fertilizers, says Cecilia Palmborg, senior researcher at SLU.

By recycling organic material in the production of fertilizers, such as digestate from biogas production, we can help ensure that nutrients and other resources are reused in food production. We evaluate the effectiveness of circular fertilizers and explore the potential for increased regional self-sufficiency in both fertilizers and food.

Phosphorus recycling to agricultural land is also an important aspect to examine more closely. Before the effects of phosphorus fertilization on crop uptake can be observed, it may take time. This is one of the reasons why our trials are conducted over three years.

Questions in the Project

- What are the fertilizer values of the digestate products that are easy to produce in the north?
- When is it beneficial for a biogas plant to invest in the processing of digestate?
- How can cereals for food be cultivated in the best possible way?
- Are there risks associated with repeated use of these fertilizers? Can they offer other benefits, such as reducing heavy metal content in crops? For example, sludge biochar can bind heavy metals like cadmium.
- Can new and circular fertilizers contribute to increased regional food security? How?
- Circular fertilizers have a lower environmental impact. The extraction of fossil fuels and minerals decreases. Nutrients are utilized where they are beneficial rather than harmful. How can this be optimized?

First Year of a Three-Year Experiment

This information sheet outlines the first of a total of three years of field trials with digestate products.

By conducting fertilization experiments on the same site for three consecutive years, we can start to observe the effects of long-term use of nitrogen fertilizers. Our experiments includes two adjacent test fields.

Different fertilizers have been used in different plots.

In the smaller trial, we are fertilizing with pig manure pellets from Alviksgården. We are testing four groups with different amounts of pellets. The results are then compared to NPK, which stands for nitrogen (N), phosphorus (P), and potassium (K). NPK represents the three most important nutrients used in fertilizers.

In the larger experiment, we compare recycled ammonium sulfate against mineral nitrogen. We also compare sludge biochar and dewatered digestate from household waste with mineral phosphorus.

In addition to the two trials, we have also chosen to combine all phosphorus and nitrogen fertilizers. This is to provide a better basis for giving fertilizer recommendations to farmers. Alongside the larger trial, we are also using liquid digestate from household waste.

An image from the cultivations at Röbäcksdalen.

Fertilizers Used in the Crop Experiments

Biochar
Produced through pyrolysis of sewage sludge at high temperatures without oxygen. This process vaporizes or burns off most contaminants like plastics and pharmaceutical residues. Sludge biochar contains a high amount of phosphorus and stores carbon in the soil more or less permanently.

Recycled Ammonium Sulfate
A fertilizer product produced by recovering ammonium from wastewater, reject water from digestate dewatering, or industrial sources. It adds nitrogen and sulfur to the soil.

Liquid Biogas Digestate
A nutrient-rich form of fertilizer produced through the breakdown of organic material, such as other fertilizers, plant residues, or other organic waste. The process occurs in a biogas plant, in an oxygen-free environment. The end products are biogas and liquid digestate, containing nutrients like nitrogen, phosphorus, and potassium.

Mineral Phosphorus
A form of phosphorus obtained by extracting minerals from mines. Phosphorus cannot be replaced by any other substance, and global reserves of phosphorus are limited. Phosphate mines are often located outside the EU and require long-distance transportation.

Combinations of Fertilizers

Combinations of fertilizers have been used in the experiments and then compared with control groups:

Nitrogen Fertilizers
Pelleted biogas digestate from Alviksgården
Recycled ammonium sulfate
Liquid biogas digestate from Härnösand

Phosphorus Fertilizers
Biochar from sewage sludge
Biochar from dewatered biogas digestate

Comparison Groups
Mineral-fertilized control groups
Unfertilized control groups

How the Experiments Were Conducted

All treatments were repeated in four different plots, randomly placed within four blocks. Each experiment is evaluated separately. The crop experiments provide harvest data based on the amount of wheat per plot. In this case, wheat quality was analyzed based on two samples per treatment. We have utilized standard methods for our agricultural experiments. The same type of methods is used in official variety trials so that our results can be compared with others.

In the larger trial, we investigate different combinations of fertilizers. These consist of nine different fertilizer options: three different nitrogen fertilizations, three different phosphorus fertilizations, and completely unfertilized controls.

In addition we also combine all phosphorus and nitrogen fertilizers to provide a basis for fertilizer recommendations to farmers (Table 1). The rows in the table show the combinations of different types of fertilizers that we use and evaluate.

The letter ”N” symbolizes mineral nitrogen, and the number indicates the quantity. For example, ”Biochar+100N” and ”Biochar+50N” mean that biochar is used together with nitrogen fertilizer at rates of 100 kg nitrogen per hectare and 50 kg nitrogen per hectare, respectively.

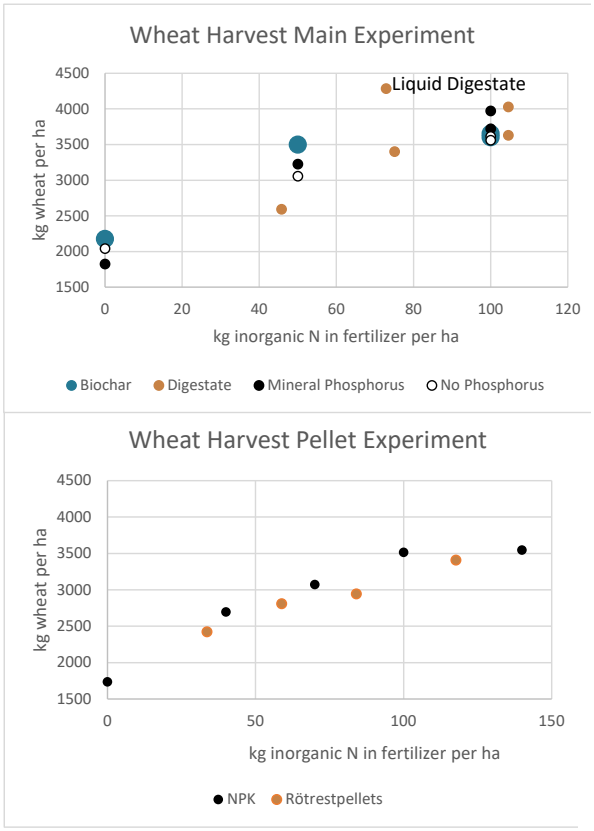
”NS” stands for ammonium sulfate. ”Mineral phosphorus+100NS” signifies mineral phosphorus in combination with 100 kg nitrogen per hectare in ammonium sulfate.

Tabel 1: Each cell represents a fertilizer combination evaluated in the experiment.

Led nr.	Fertilizer
1	Biochar+ 100 N
2	Biochar+ 50 N
3	Biochar+ 100 NS
4	Biochar+ 0 N
5	Dehydrated digestate+ 59 N
6	Dehydrated digestate+ 29 N
7	Dehydrated digestate+ 59 NS
8	Dehydrated digestate+ 0 N
9	Mineral phosphorus + 100 N
10	Mineral phosphorus + 50 N
11	Mineral phosphorus + 100 NS
12	Mineral phosphorus + 0 N
13	100 N
14	50 N
15	100 NS
16	Unfertilized
17	Liquid digestate 110 N

Harvest Results

Upon analyzing the harvest results, it can be concluded that to achieve the same crop yields as traditionally used mineral fertilizer nitrogen provides, an equivalent amount of plant-available nitrogen (ammonium and nitrate) needs to be supplied in the circular fertilizer alternatives. Additionally, a significant increase in grain size, also known as thousand grain weight, was observed when more nitrogen was applied. The size increased when the amount of applied nitrogen was between 100-140 kg per hectare. This was observed in both the experiments with fertilizer from Alviksgården and for dewatered digestate.



Figur 1 & 2: Mean wheat yield values for each treatment against the total amount of ammonium+nitrate in circular fertilizer + mineral fertilizer treatments in the two fertilization experiments.

Harvest in full swing at Röbäcksdalen in the fall of 2023.

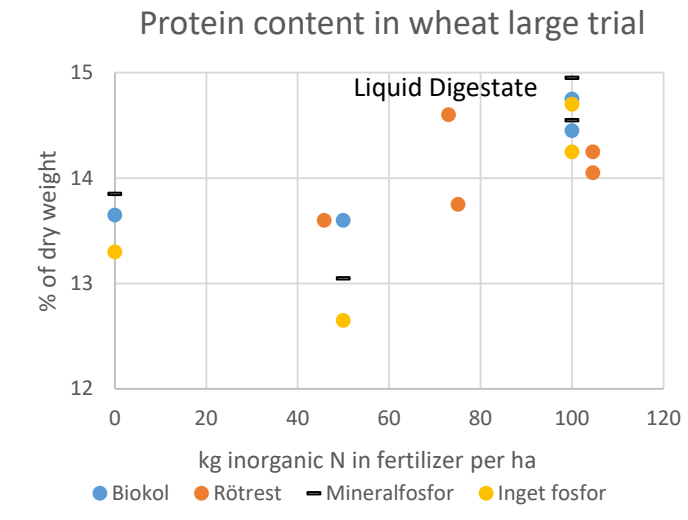
Importance of Adding Nitrogen for Increased Protein Content

For bread wheat, protein content is crucial, and to fetch the highest price for farmers, it needs to be higher than 13.5%, which qualifies for the highest quality class. It's important to achieve the same high protein levels with digestate products as with mineral fertilizers. Good nitrogen sources can help ensure that wheat reaches the desired protein content for bread production.

Harvest time for the cultivation at Röbäcksdalen, Umeå

In our large-scale trial, approximately 70 kg of inorganic nitrogen per hectare was required to raise the protein content to the highest quality level in the wheat grown (Figure 3). In the trial with digestate pellets the protein content was above 13.5% in all cases observed.

For liquid biogas digestate, the results suggest that nitrogen bound in organic compounds has also become available to the wheat. This can have a positive effect on both protein content and the size of the wheat harvest. Biogas digestate from sorted household waste often contains easily decomposable organic material that can provide nitrogen already in the first growing season.



Figur 3: Mean protein content values for each treatment in the large-scale experiment

Falling number; A Measure of Startch's Ability to Gelatinize

Falling number is a measure of starch's ability to gelatinize, where higher values indicate better quality. For spring wheat for baking, the minimum level for viscosity is 200. Values below 250 result in price deductions. The analysis is costly and performed selectively. In our experiments, results ranged from 235 to 266 for a full dose of mineral fertilizer or ammonium sulfate, while liquid digestate showed a low value of 196. Wheat fertilized with 100 kg of nitrogen from digestate pellets also had a low value, 210, which is close to the threshold for feed wheat rather than bread wheat. Our low values are probably due to the rainy autumn.

In addition to falling number, bulk density and ergosterol are important for wheat quality assessment. All samples were approved in these aspects. Phosphorus fertilizer generally had less impact compared to nitrogen fertilizer.

Conclusion

The experiment shows that it is possible to grow bread wheat in northern Sweden using recycled fertilizers.

More Information

This information sheet presents results and observations from the first of three trial years running from 2023 to 2025. We are happy to provide more information and will publish further results in due course. Please feel free to reach out with any questions.

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Cecilia Palmborg, SLU, have analyzed data from the first experiment.

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Co-funded by the European Union