NUTRI•KNOW

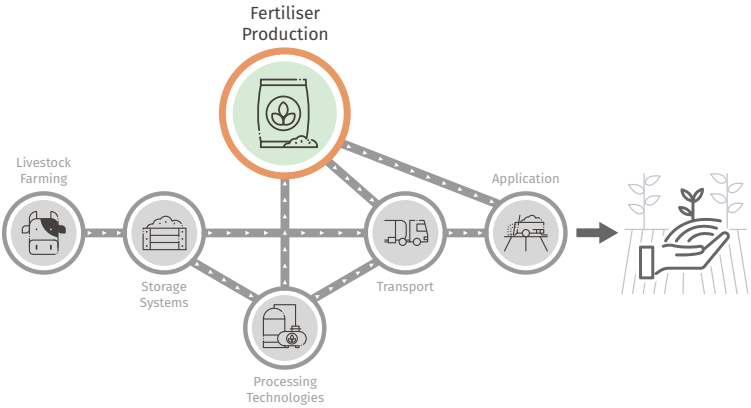
Fertiliser Production

Technologies, tools and recommended practices from NUTRI-KNOW's EIP-AGRI Operational Groups

Introduction

Agricultural by-products such as animal manure and processing by-products are rich in essential nutrients including nitrogen (N), phosphorus (P) and potassium (K). Although they are considered agricultural by-products, they have the potential to be used raw or be further processed into products to displace mineral fertiliser reliance. In some cases, nutrients such as N which can be lost to the environment as ammonia-N for example can be captured and retained as fertiliser. Using recycled and recaptured nutrients as fertilisers in agriculture helps to close the nutrient cycle loop and can develop the local bioeconomy.

This booklet gives an overview of the fertiliser production experiences, decision support tools, technologies and recommendations that are the outcomes of five EIP- AGRI Operational Groups related to nutrient management. These groups and associated projects have focused on producing fertilisers from agricultural by-products such as grass and manure. Furthermore, they provide knowledge on nutrient management and how the production of biobased-recycled fertilisers can reduce environmental pollution. They do this by capturing mineral fertiliser equivalent nutrients, which would otherwise be lost in the form of ammonia and greenhouse gas (GHG) emissions and contribute to the efficient and predictable use of nutrients.



Fertiliser Production

Innovative and environmentally conscious management of agricultural by-products as fertilisers can help to empower farmers and change their role in the bioeconomy from being suppliers of cheap biomass into producers of bio-based products. Fertilisers presented here are produced from low-quality grass or animal manure using cutting-edge technologies, which have undergone various treatment stages that can be used directly on the farm. For more information see the links to the home pages of the Operational Groups presented below.

Bio-Based Fertilisers and **Organic Farming**

The development of bio-based fertilisers is a promising approach to support nutrient management needs on organic farms, particularly on stockless farms, where links between arable and livestock enterprises may not be established. In contrast to many non-organic farms, organic crop nutrition is primarily based on biological aspects of soil fertility rather than a focus on nutrient supply. As a result, the import of bio-based fertilisers should be part of a farm's broader management strategy which aims to maintain long-term soil fertility for yield optimisation but avoids dependency on external inputs. Under EU organic legislation all bio-based fertilisers must be authorised for use in organic production.

Nitrogen Fertiliser From **Manure**

Stripping-scrubbing is an innovative approach that can be applied locally on the farm to process nutrients from manure to ammonium salts as RENURE (REcovered Nitrogen from manuRE) products. Ammonium salts are high in N in a form that is readily available to the crop. Production of RENURE products as a substitution for synthetic nitrogen fertilisers addresses issues of nutrient surplus from animal sources at a local level and reduces fertiliser costs.

Stripping-scrubbing installation

Field trials to assess ammonium nitrate as a fertiliser on potato and maize plots after an initial application of animal manure indicated that it can perform just as well as artificial fertiliser (urea and calcium ammonium nitrate) in terms of effectiveness and nutrient value.

Benefits

- In some cases, crops treated with ammonium nitrate performed better than the reference, although this was partly due to heterogeneity due to the dry growing season.
- Ammonium nitrate was compatible with a row tiller for fertilising potatoes and for injection with a seeder when sowing maize.

- Presently, these fertilisers are classified as animal manure and must therefore comply with the Nitrates Directive 91/676/EEC. At the time of writing (May 2024) a consultation process is in place by the European Commission to amend the Directive to permit the use of specific RENURE fertilisers to improve substitution of chemical fertilisers by organic fertilisers. This includes ammonium salts, reverse osmosis mineral concentrates and struvite.
- Although stripping scrubbing-derived ammonium nitrate has a lower N content than synthetic N fertiliser, it has excellent potential as a substitution for synthetic fertiliser, as it can be produced locally on the farm, and it also has the potential to increase the farmer's income.

Ammonium salts are produced from the Stripping-scrubbing process

Application of ammonium salts to grass through injection

Nutrient Content

The nutrient value of ammonium nitrate (10-15% N) as a fertiliser, after an initial application of animal manure performed comparably to artificial fertiliser.

Current Status

The ammonium salts are produced at a pilot scale and used on arable farms with full-scale operations taking place in Belgium, Detricon, at Gistel (Flanders) and Strocon, at Hooglede (Dutch) as part of the NITROMAN project. Results of a meta-analysis in this Operational Group suggested that the capacity of a stripping-scrubbing installation should be at least about 20,000 tons of manure per year to achieve the desired economies of scale.

More information can be accessed at the home page of the Operational Group **RENURE**

Nitrogen Fertiliser From the **Air** of **Pig Housing**

The Gas Loop Operational Group has developed an innovative technology to remove ammonia from the air of pig housing and recover it in an ammonium sulphate solution closing the N cycle loop. Nitrogen, an essential nutrient is often emitted as harmful ammonia which can have negative effects on animals, the environment and human health. This technology captures ammonia-N and repurposes it into fertiliser, preventing its escape. The air treatment is based on the chemical absorption of ammonia by backwashing with an acid reagent in a tower. Sulfuric acid solution (H_2SO_4) reacts with ammonia (NH_3) to form a stable suspension of ammonium sulphate ($(NH_4)_2SO_4$) (typically 6% N and 8% S) which accumulates in a tank at the base of the washing tower.

The treatment was tested for 2 years in fattening cycles of pigs for the PDO Parma ham supply chain, and it produced ammonium sulphate fertiliser using air-washing technology and a chemical characterisation was conducted. The ammonium sulphate solution recovered reduced GHG emissions by replacing N industrial fertilisers.

Ammonium sulphate fertiliser

Benefits

- This “air washing system” improves animal welfare and increases productivity due to better air quality inside the pig housing.

- Ammonia present in the air inside the pig house is recovered as an ammonium sulphate solution and this solution can then be valorised as a mineral N fertiliser. The ammonia capture system from the air of a pig livestock house allows the recovery of 14.5kg of N per year and per tonne of pig live weight housed and therefore avoids 66kg CO_2 equivalent per tonne of pig live weight per year by evading the production of the same quantity of synthetic N fertiliser.

Ammonium sulphate produced

- The production of the ammonium sulphate solution (230 litres per tonne of pig live weight per year) is characterised by pH 4, by a Total Nitrogen content of 6% (99% as ammonia-N) and by a Total Organic Carbon of 1% in weight.
- Up to 14.5 kg N per tonne of live weight per year was recovered and up to 1.94kg ammonia per animal place per year of ammonia emissions into the atmosphere was prevented.
- In a pig farm with an average live weight of 1,150 tonnes (around 10,500 fattening places), 16.8 tonnes of N per year could be recoverable.

Nutrient Content

Total Nitrogen content of 6% (99% as ammonia-N).

Current Status

The air treatment is presently running, and the ammonium sulphate produced is currently used at farm scale. The ammonium sulphate fertilisers recovered are classified under the EU fertiliser regulation as liquid inorganic N fertilisers under Product Function Category 1,

More information can be accessed at the home page of the Operational Group **GAS LOOP**

Production of **Struvite Fertiliser** From **Manure** and **Digestate**

In Italy, there are areas with a high level of livestock where optimal management of manure and digestates could lead to a reduction in emissions. Digestate or manure treatment can favour the delocalisation of the N and P surpluses from areas with high livestock farming towards areas characterised by a demand for chemical fertilisers, following the principles of Nutrient Recovery and Reuse.

New technology has been developed to produce an organic fertiliser, namely struvite ($NH_4MgPO_4 \cdot 6H_2O$). This slow-release renewable recovered fertiliser is high in key nutrients P, N and magnesium (Mg), which can be used to replace synthetic fertilisers in areas characterised by nutrient deficiencies. The efficiency of recovering P and N was higher with pre-acidification of the digestate (digestate pH reduced to 7.5 from the starting value of 8.5) followed by microfiltration to remove the solids. The addition of Mg and alkaline (to increase pH from 7.5 to 9) promoted the development of crystals and their precipitation. The P, N and Mg were concentrated in the precipitate. At this stage, the P and N were suspended in saline, in a stable form and no longer in an orthophosphoric and ammonia form.

Struvite production pilot treatment plant

Benefits

- The precipitate containing struvite can be utilised by fertiliser producers or used as a raw material for producing phosphate fertilisers.
- By reducing P, N and dry matter content of livestock manure and digestates, ammonia, methane and nitrous oxide emissions were reduced from the liquid digestate storage and the soil application phase.

Current stage of struvite refinement, struvite-rich precipitate

Nutrient Content

P, N and magnesium (Mg), respectively 13%, 6% and 11%, in case of refined and pure products. The precipitate containing struvite is currently in a liquid form and should be dried according to the water content.

Current Status

The struvite-containing precipitate fraction requires additional refinement—such as drying, cleaning, and granulation by a fertiliser manufacturer—to replace phosphate minerals with phosphorus recovered from manure or digestate. This ensures it better meets the new European fertiliser regulation's P Component Material Categories and users' needs. The high concentration of water, solids and organic matter in the recovered matrices rich in struvite is still a critical issue. The OG Struvite has ended, but the research and activities are not concluded, they will be continued in a new Struvite project.

More information can be accessed at the home page of the Operational Group **STRUVITE**

Using **Grass Juice** to **Cultivate Algae**

Grass2Algae has developed a novel approach to increase the value of roadside grass or low-quality grass, which typically has poor animal feed value and is often treated as waste. This new farm-based technology allows the liquid fraction of grass to be separated from the fiber fraction by a sequence of sedimentation, coarse filtration and pH adjustments. This nutrient-rich grass juice can be used by farmers as an alternative fertiliser to cultivate algae that can be produced locally on the farm and sold as high-protein animal feed displacing protein imports.

Microalgae cultivation using grass juice at lab-scale

Microalgae cultivation using grass juice at pilot scale - Picture taken on Kris Heirbaut's farm

Benefits

- Grass juice is rich in macro and micronutrients that are necessary for the growth of microalgae.
- It can replace mineral fertilisers and increase the sustainability of algae production.
- Results from microbial analysis and the algae product showed the quality of biomass produced is up to specifications for food application resulting in a new source of income for farmers.

Nutrient Content

- The carbon content and nutrients in grass juice included total carbon 6717mg/l, total nitrogen 520mg/l, ammonium (NH_4-N) 97mg/l, nitrate (NO_3-N) 11mg/l, P 192mg/l and K 2215mg/l.
- The produced algae biomass had 17% moisture (partially dried), 41% total protein, 27% total carbohydrates, 12% total fat, 3% crude fibre and 17% inorganics.

Current Status

Currently the grass juice is mainly produced at the farm level and used at the same farm at a pilot scale for algae cultivation.

More information can be accessed at the home page of the Operational Group **Grass2Algae**

Grass Whey Fertiliser

Biorefinery Glas developed a system to increase the value of grass using a small-scale biorefinery. This is useful where the feedstock scale required for integration with anaerobic digestion may not be achievable. In the biorefinery, the grass is crushed, and the solid press cake can be used as feed for cattle. The liquid by-product or grass whey is nutrient-rich and can be recirculated back to the land in the form of fertiliser. This fertiliser is produced and spread locally on the farm, ensuring the nutrients remain on the farm.

GRASSA small-scale biorefinery located in the West Cork Region, Ireland

Grass whey from crushed and pressed grass is produced in the biorefinery

Field trials to evaluate the use of whey as a fertiliser compared to slurry were conducted, using a spreading rate of 30 m^3/ha and low-emission slurry spreading.

Benefits

- Grass whey performed comparably to cattle slurry as a fertiliser for grass.
- Grass treated with whey was 'deeper' in colour compared with the slurry-treated grass, possibly due to more chlorophyll being available, as grass whey also acts as a bio-stimulant.
- A sweet and pleasant smell was also noticed from the spreading of whey compared with the slurry.
- Grass whey production can increase the value of grass for farmers and reduce their fertiliser costs.

The liquid grass whey is collected and spread as a bio-based fertiliser

Nutrient Content

The nutrient values (N, P and K) of the grass whey and slurry were comparable.

Current Status

Grass whey is currently produced on a farm level at a pilot scale.

More information can be accessed at the home page of the Operational Group **Biorefinery Glas**

Summary

Tools to **Help Farmers**

- Valorise grass from field margins or other low-quality grass that cannot be used as feed and is often deemed as waste. *(OG Biorefinery Glas)*
- Capture of N from animal housing ammonia emissions as ammonium salts which is a by-product of air treatment. *(OG Gas Loop)*
- Assess struvite production using manure or digestate as the P feedstock. *(OG Struvite)*

Technologies and **Recommendations**

- Reducing ammonia and GHG emissions by converting ammonia emissions into ammonium sulphate fertiliser and limiting emissions by producing slow-release renewable recovered fertiliser as struvite, which has the potential to replace conventional mineral N and P fertilisers. *(OGs Gas Loop, Struvite, RENURE)*
- Production of nutrient-rich grass juice by biorefineries and separation technologies has the potential to replace mineral fertilisers and slurry, supporting the sustainable growth of algae and grass production. *(OGs Biorefinery Glas, Grass2Algae)*

Future Benefits

- Locally produced fertilisers ensure that the nutrients remain on the farm, harnessing a zero-waste approach.
- Potential to increase farmers' income by converting waste by-products into high-value nutrient-rich fertilisers.
- Encourage the balancing of the nutrients from manure between regions characterised by a surplus or a deficit.
- Decreasing dependencies on mineral fertilisers, reducing import and transport costs, therefore, contributing to the circularity of the bioeconomy.

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