Nutri2Cycle

D7.6 Practice abstracts of ongoing work - end term update

Deliverable:	Practice abstracts of ongoing work - end term update
Author(s):	Nutri2Cycle consortium
Quality review:	Final version
Date:	30/09/2023

Grant Agreement N°:	773682
Starting Date:	01/10/2018
Duration:	60 months
Coordinator:	Prof. Erik Meers, Ghent University
Contact details:	Erik.meers@ugent.be

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Table of content

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Glossary

Life cycle assessment: Life cycle assessment or LCA is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service

Practice abstract: short summaries of around 1500 characters according to a fixed format, describing a main information/recommendation/practice that can serve the end-users in their daily practice.

Research line: is defined as a research domain that characterizes a cluster of solutions being researched in frame of the project ; Nutri2cycle has 5 distinct research lines

Solution: a Nutri2Cycle solution is a proposed optimized farming system, aimed at closing nutrient loops and efficient mitigation measures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

List of abbrevations

This is a list of very general abbrevations, practice abstract specific abbrevations are explained within the practice abstract

D:	Deliverable
EIP-AGRI:	Agricultural European Innovation Partnership
EU:	European Union
GHG:	Greenhouse Gas Emsissions
P:	Phosphorus
PA:	Practice Abstract
N:	Nitrogen

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

1. Introduction

The Nutri2Cycle project is committed to ensuring a continuous exchange of knowledge with interested stakeholders through different channels and throughout all stages of the project and well beyond project-ending.

As a H2020 multi-actor innovation project Nutri2Cycle's projects objectives, ambitioned results and outcomes are highly orientated towards demand driven, practical knowledge for rapid implementation in the field. For this reason the project cooperates very closely with farmers, farmers 'groups, EIP operational groups in the different EU member states, etc. To also reach broad dissemination of the results the project has also committed to feed the results into the EIP-AGRI website.

The agricultural European Innovation Partnership (EIP-AGRI) works to foster competitive and sustainable farming and forestry. Through the EIP-AGRI's website, users can share innovative project ideas and practices, information about research and innovation projects, including projects' results. To facilitate knowledge flows on innovative and practice-oriented projects from the start till the end of the project, the EIP-AGRI sets a common format, the so-called "practice abstract" to European projects. The use of this format also enables farmers, advisors, researchers and all other actors across the EU to contact each other.

In the previous reporting periods, the consortium published 27 practice abstracts, presenting the major research lines that have been managed within Nutri2Cycle and the early research results (see deliverables D7.4 and D7.5). This particular follow-up deliverable D7.6 compiles all the practice abstracts that were developed from the start of the project, with 22 new practice abstracts focusing on the final results and outcomes of the Nutri2Cycle solutions. In total, 49 practice abstracts were submitted to the EIP-AGRI website in the project lifetime.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

The table below lists the 49 practice abstracts published and submitted over the course of the project and their publication status on the EIP- AGRI website. The practice abstracts are also grouped according to the research lines developed under Nutri2Cycle (see the Annex). The 27 practice abstracts published in the EIP-AGRI network can be found via this link: https://ec.europa.eu/eip/agriculture/en/find-connect/projects/transition-towards-more-carbon-and-nutrient.html

PA nr	PA title	Status	Target audience
PA 1	Reducing EU's dependence on protein import (e.g. soy bean) by local production of novel animal feeds from agro-residues	Published	All stakeholders
PA 2	Substituting primary resources by biobased products for a more sustainable European agriculture	Published	All stakeholders
PA 3	Solutions for more nutrient efficient plant production as investigated by the H2020-NUTRI2CYCLE project	Published	All stakeholders
PA 4	Innovative solutions for optimized nutrient husbandry	Published	All Stakeholder
PA 5	Enhanced recycling of (organic) carbon within European agricultural systems	Published	All stakeholders
PA 6	Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment	Published	Arable land farmers, advisors, researchers, policy makers
PA 7	Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers	Published	Animal Husbandry, (pig) farmers, researchers
PA 8	Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency	Published	Animal husbandry farmers, researchers
PA 9	A study case on the use of digestate as bio fertilizer: characterization and environmental assessment	Published	Biogas operators ; arable land farmers, researchers, policy makers
PA 10	Closing the loops at farm scale : using livestock manure to fertilize feeding crops on agroforestry plots	Published	Farmers in general yet with interest toward mixed farming systems in particular
PA 11	Substituting mineral inputs with organic inputs in organic viticulture	Published	Viticulture farmers
PA 12	Partial substitution of mineral fertilizers by animal manures in an apple orchard	Published	Animal husbandry farmers,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

PA 13	Enhanced manure recycling by producing manure-based fertilizers	Published	Animal husbandry, arable farmers, researchers
PA 14	Use of digestate in orchards	Published	Arable farmers
PA 15	*Lemna minor* cultivation for treating swine manure and providing micronutrients for animal feed	Published	Animal husbandry, pig farmers, policy makers, feed industry
PA 16	Poultry and chicken manure management - practical considerations in Polish conditions	Published	Poultry farmers
PA 17	Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment – 2nd year	Published	Animal husbandry, pig farmers, researchers
PA 18	Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil	Published	Arable farmers, policy makers
PA 19	Producing bio-fertilisers from pig manure through different separations stages	Published	Animal husbandry farmers,
PA 20	Are consumers willing to pay a premium price for sustainable food?	Published	All stakeholders
PA 21	Refining bio-based fertiliser has limited effect on potato yield	Published	Animal husbandry farmers, advisors
PA 22	Precision farming and optimised application: under-root application of liquid manure for maize and other row crops	Published	Arable land farmers, advisors
PA 23	Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO- NPK-C formulations	Published	Fertiliser companies, arable farmers, policy makers
PA 24	Poultry manure derived biochar as a sorbent for removal of various contaminants	Published	Poultry farmers, researchers
PA 25	Fertilizing products from poultry manure	Published	Poultry farmers, researchers
PA 26	Energy recovery from poultry manure	Published	Biogas operators
PA 27	Using soil electrical conductivity and NDVI to identify distinct fertilizing areas in a vineyard	Published	Arable farmers, researchers
PA 28	Farm scale anaerobic digestion of agro-residues to increase local nutrient cycling & improve nutrient use efficiency	Submitted	Arable land farmers, biogas operators
PA 29	Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment	Submitted	Arable land farmers, advisors, researchers, policy makers
PA 30	Why we should dive into potassium when growing duckweed	Submitted	Farmers
PA 31	Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil	Submitted	Arable farmers, policy makers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

PA 32	Producing bio-fertilisers from pig manure through different separations stages	Submitted	Animal husbandry farmers, policy makers
PA 33	Environmental and social life cycle assessments of nutrient recovery technologies in agriculture	Submitted	Farmers, policy makers
PA 34	Life cycle assessment of black soldier fly rearing on agricultural residues	Submitted	Farmers, policy makers
PA 35	Life cycle assessment of constructed wetlands and duckweed ponds for treating liquid manure	Submitted	Farmers, policy makers
PA 36	Life cycle assessment of pig slurry acidification under Danish natural and regulatory conditions	Submitted	Farmers, policy makers
PA 37	Life cycle assessment of pig slurry acidification under Dutch natural and regulatory conditions	Submitted	Farmers, policy makers
PA 38	Life cycle assessment of pig slurry acidification under Spanish natural and regulatory conditions	Submitted	Farmers, policy makers
PA 39	Use of poultry manure compost and pig slurry to replace mineral fertilizers used as basal fertilization in maize crop	Submitted	Animal husbandry farmers
PA 40	Ammonia recovery from raw pig slurry in a vacuum evaporation field pilot plant	Submitted	Farmers, researchers
PA 41	3R upcycling process for BIO-NPK-C compound biofertilizers to create user benefits	Submitted	Farmers
PA 42	Microalgae cultivation in digestate for sustainable and local protein production	Submitted	AD plant managers and farmers with an AD system
PA 43	Findings from bio-based fertiliser trial within an Irish cropland setting	Submitted	Farmers
PA 44	Emissions from plasma treated sludge	Submitted	Farmers, advisors
PA 45	Application of BioBased Fertilizer on potato in sandy soil	Submitted	Farmers, advisors, policy makers
PA 46	Precision Application of manure in potato	Submitted	Farmers, advisors, policy makers
PA 47	Substituting mineral inputs with organic inputs in organic viticulture	Submitted	Viticulture farmers
PA 48	Circular economy and fertilization: recycling of livestock effluents on agro-forestry plot.	Submitted	Farmers
PA 49	Using precision technologies in plants nutrient management	Submitted	Farmers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

2. Compilation of practice abstracts

Practice abstract 1

Short title (native language):

PA1: Reducing EU's dependence on protein import (e.g. soy bean) by local production of novel animal feeds from agro-residues

Short summary for practitioners (native language)

Introduction

The Nutri2Cycle project aims to enable the transition from the current suboptimal nutrient household in European agriculture to the next-generation of agronomic practices, characterized by an improved upcycling of nutrients and organic carbon. Developing local protein sources from nitrogen containing waste & waste water streams to reduce import dependency, is one of the strategies investigated within the Nutri2Cycle project.

Research focus

The animal husbandry sector is characterized by massive intercontinental import of soy bean products. Substitution of these products by locally produced alternatives could greatly improve nutrient stewardship within this economically important sector. Within Nutri2Cycle an important research line is the production of novel animal feeds. One the one hand we will focus on direct replacement by exploring the possibility of domestic cultivation of protein crops. However, another important research aspect will be to search for novel sources of proteins such as insect breeding, floating wetland plants and algae. Interestingly these novel sources could be grown on solid or liquid agro residues. Successful implementation of this approach could not only reduce the import of external protein sources but at the same time prevent nutrient loss by recuperating the nutrients from these otherwise low value side streams. The most promising pathways as compared to the common practice will be demonstrated in an operational environment and the transferability in the EU will be assessed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 2

Short title (native language):

PA2: Substituting primary resources by biobased products for a more sustainable European agriculture

Short summary for practitioners (native language)

Introduction

Intensified European agriculture is crucial for the EU food supply and self-sufficiency, but it also generates environmental challenges related to GHG emissions and nutrient related pressure (eutrophication). In addition, European agriculture is under economic pressure due to its high dependency on import of primary nutrients and energy. The Nutri2Cycle project aims to enable the transition from the current suboptimal nutrient household in European agriculture to the next-generation of agronomic practices, characterized by an improved upcycling of nutrients and organic carbon. In this respect a great opportunity lies within the use of biobased fertilizers and soil enhancers from agro residues as a substitute for primary resources.

Research focus

Within Nutri2Cycle we want to further enhance nutrient recovery technologies at farm level such as struvite crystallization, stripping/scrubbing, etc.. with the goal of replacing mineral fertilizers. At the same time the efficiency of the resulting novel fertilizers will be tested in comparative field trials to evaluate their performance, stability towards composition, contribution to soil fertility and nutrient use efficiency in comparison with their mineral counterparts. This will be an important step towards tailor designed fertilizers The most promising pathways as compared to the common practice will be demonstrated in an operational environment and the transferability in the EU will be assessed. This should ultimately lead to a higher soil quality, more efficient use of resources, and a reduction of nutrient losses to the environment. As a result, significantly less synthetic N and P fertilizer inputs will be needed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 3

Short title (native language):

PA3: Solutions for more nutrient efficient plant production as investigated by the H2020-NUTRI2CYCLE project

Short summary for practitioners (native language)

Introduction

The Horizon 2020 project Nutri2Cycle aims at implementing optimized management systems to realize better nutrient stewardship and mitigation in European agriculture. Contemporary plant production has increasingly required nutrients in directly available form such as mineral fertilizers to obtain the highest possible productivity and economic efficiency. The major challenge now is to maintain this high productivity and product quality at lower environmental impact. A key element in this will be reconnecting the two classical pillars of plant production and animal husbandry through a third pillar of agro-processing. This leads to a range of processed residues or so called bio based fertilizers that now need to be aligned with plant production requirements

Research focus

Different tools, techniques and systems for higher precision fertilization could play an important role in this, not only for the application of classic fertilizers, both definitely for novel bio based fertilizers which are characterized by a higher variability in nutrient content. Within the Nutri2Cycle project research will be conducted on precision fertilization tools such as the use of drones, optical sensing technology and nitrate sensoring to cope with the heterogeneity of bio based fertilizers and better alignment of fertilizer dose with actual crop demand (tailor made products). The most promising pathways as compared to the common practice will be demonstrated in an operational environment and the transferability in the EU will be assessed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 4

Short title (native language):

PA4: Innovative solutions for optimized nutrient & GHG in animal husbandry

Short summary for practitioners (native language)

Introduction

The Horizon 2020 project Nutri2Cycle aims at implementing optimized management systems to realize better nutrient stewardship and mitigation in European agriculture. Contemporary animal production has been characterized by upscaling and increased animal concentrations. This has been crucial for the European Union food supply and self-sufficiency, but has also lead to nutrient related pressure and greenhouse gas emissions. The challenge now is to drastic reduce emissions through combinations of emission abatement and manure treatment technologies.

Research focus

Within Nutri2Cycle different strategies will be examined to achieve these goals. To reduce ammonia emissions and optimize nutrient use efficiency the use of inoculation of microbiota and enzymatic precursors will be investigated in poultry manure, while for animal slurry the effect of acidification on reduction of NH3 volatilization will be examined. Also, the project will investigate innovative stable construction schemes, which intend to source-separate feces and urine into separate flows (as opposed to mixed slurry). Processing these flows separately can result in more optimal energy and N-P-C cycles than conventional manure handling. Different anaerobic digestion strategies for optimized nutrient and energy recovery from animal manure will also be investigated and the option to make tailor made digestate products will be explored. The most promising pathways as compared to the common practice will be demonstrated in an operational environment and the transferability in the EU will be assessed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 5

Short title (native language):

PA5: Enhanced recycling of (organic) carbon within European agricultural systems

Short summary for practitioners (native language)

Introduction

European agriculture is characterized by a high overall contribution to greenhouse gas (GHG) emissions and inefficient recovery and re-use of major plant nutrients such as nitrogen and phosphorus. In this respect, carbon has been insufficiently by policy makers as a key component of soil fertility and health. The Nutri2Cycle project wants to address the current gaps in the cycles of mineral nutrients as well as organic carbon for different European agricultural systems through implementation of technologies which enhance recycling from (agro)residues.

Research focus

An important research line will be investigating innovative soil, fertilization and crop management systems and practices that could lead to maintaining and increasing organic carbon (OC). This will for example include (i) field trials to assess the use of catch crops to reduce nitrogen losses and incorporate additional OC, (ii) field investigation in Northern Italy on using digestate derived products to supplement soils lacking OC and doing so in a balanced (precision fertilization) manner so that mineral nutrient supply also remains in balance with crop requirement, (iii) an assessment of Dutch farming practices for increasing soil OC, (iv) utilization of a combination of manure and dairy processing residues in crop farming. The most promising pathways as compared to the common practice will be assessed for transferability in the EU.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 6

Short title (in English):

PA6: Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment

Introduction

Large surpluses of on-farm nitrogen (N) and phosphorus (P) are processed or exported out of Flanders in the form of animal manure, while tonnes of synthetic N-fertilisers are being used. The use of recycling- derived fertilisers (RDFs) from manure could counter this. Currently, RDFs derived from manure still need to comply with the legal application constraints of animal manure and are thus not often used. That is why five RDFs: ammonium nitrate, ammonium sulphate, digestate from co-digestion of pig manure, liquid fraction of digestate and pig urine, are compared with mineral fertiliser CAN, pig manure and a blank treatment in a 3-year field trial focusing on short term N-effects of the RDFs. The main goal of the trial is to establish a clear relationship between the amount of N applied by RDF and dry matter production. Each RDF was applied in 4 doses. Currently we are one year into the 3 year trial. Weather conditions during the summer months 2019 were extremely dry and hot. Therefore water availability became the principal factor determining crop growth. Lab analysis showed that N and P content could vary up to 50% in different samples in time of pig manure, digestate, liquid fraction from digestate or pig urine. In these extreme conditions the agricultural value of ammonium nitrate and ammonium sulphate appears to approach that of CAN. Furthermore, no significant differences with respect to residual nitrate in the soil profile at harvest are observed for treatments with high Nmin/Ntot ratio when good practices are adopted towards applied dosage based on initial available nitrogen in the soil, good knowledge of composition (considering higher variability of biobased fertilizers as compared to synthetic fertilizer), timing of application etc.

Short title (native language):

Korte stikstof termijneffect van herwonnen meststoffen met focus op gewasopbrengst en stikstofverliezen naar het milieu

Short summary for practitioners (native language)

Het mestoverschot in Vlaanderen wordt verwerkt en geëxporteerd in de vorm van dierlijke mest, terwijl kunstmest grootschalig wordt aangekocht. Nochtans kan het gebruik van herwonnen meststoffen dit oplossen. Deze herwonnen meststoffen dienen echter te voldoen aan de wettelijke toepassingsvereisten van dierlijke mest en worden dus niet vaak gebruikt. In een 3 jaar durende veldproef werden de korte stikstof termijneffecten van vijf herwonnen meststoffen: ammoniumnitraat, -sulfaat, digestaat van co- vergisting van varkensmest, dunne fractie van digestaat en varkensurine, uitgetest en vergeleken met KAS kunstmest, varkensmest en een blanco

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

behandeling. Hierbij wordt getracht een verband te leggen tussen de hoeveelheid N die door de meststof wordt aangebracht en de droge stofproductie. Elke meststof werd in 4 dosissen aangebracht. Momenteel is het eerste jaar van de veldproef afgerond. De weersomstandigheden in de zomer van 2019 waren extreem droog en warm. Daarom bepaalde voornamelijk de waterbeschikbaarheid de gewasopbrengst. Labo-analyses toonden dat het N- en P-gehalte tot 50% kan variëren in verschillende stalen van varkensmest, digestaat, dunne fractie van digestaat of varkensurine. Onder deze omstandigheden lijkt de bemestingswaarde van ammoniumnitraat en ammoniumsulfaat die van kunstmest te benaderen. Bovendien konden geen significante verschillen voor het nitraatresidu in het bodemprofiel bij de oogst worden waargenomen voor de behandelingen met een hoge Nmin/Ntot ratio wanneer goede praktijken werden gehanteerd voor dosering in functie van de initieel beschikbare stikstof in de bodem, exacte samenstelling (hogere variabiliteit bij biogebaseerde meststoffen), tijdstip van applicatie enz.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 7

Short title (in English):

PA7: Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers

Short summary for practitioners (in English):

Anaerobic digestion (AD) technology promotes the bioconversion of livestock waste, apart from other organic waste streams (such as those from the agrifood industry), into methane and carbon dioxide, allowing its energetic valorization. However, AD does not significantly reduce the concentration of nitrogen or phosphorus, and it is essential in all cases to carry out a nutrient balance before applying the digestate to farmland in order to minimize the environmental impact and, in many cases, it is essential to resort to techniques for reducing or recovering these nutrients. The crystallization of nitrogen and phosphorus in the form of struvite ($MgNH_4PO_4 \cdot 6H_2O$), is one of the possible techniques used to eliminate and/or recover nutrients from the digestate, obtaining a product that can be applied as a base for high quality ecological fertilizers. Several factors influence the struvite precipitation: the chemical composition of the residual effluent, the pH, the molar ratio of Mg:N-NH_4:P-PO4 (Mg:N:P), the degree of supersaturation, the temperature and the presence of foreign ions (such as calcium). In the investigated pilot struvite reactor, the reaction takes place at room temperature or similar (25-30 ºC), so there is no large energy consumption and there is no need to add water. As raw materials the following were used: pig slurry digestate, magnesium salt (usually $MgCl_2 \cdot 6H_2O$) and NaOH. The technology has been demonstrated at a sufficiently relevant scale (crystallization reactor with a capacity of 50 L), so that the results can be used for subsequent implementation on an industrial scale. Phosphorus removal yields of over 95% have been obtained.

Short title (native language):

Recuperación de nitrógeno y fósforo del purín de cerdo mediante la cristalización de estruvita y síntesis de fertilizantes a medida basados en estruvita

Short summary for practitioners (native language):

La tecnología de digestión anaeróbica (DA) promueve la bioconversión de los residuos agroganaderos, además de otros residuos orgánicos (como los de la industria agroalimentaria), en metano y dióxido de carbono, permitiendo su valorización energética. Sin embargo, la DA no reduce significativamente la concentración de N o P, y es esencial en todos los casos realizar un balance de nutrientes antes de aplicar el digestato a las tierras de cultivo para minimizar el impacto ambiental y, en muchos casos, es esencial recurrir a técnicas de reducción o recuperación de estos nutrientes. La cristalización de nitrógeno y fósforo en forma de estruvita ($MgNH_4PO_4 \cdot 6H_2O$), es una de las posibles técnicas utilizadas para eliminar y/o recuperar nutrientes del digestato, obteniendo un producto que puede ser aplicable como base en fertilizantes ecológicos de alta calidad. Varios factores influyen en la precipitación de la estruvita: la composición química del efluente residual, el pH, la relación molar de Mg:N-NH_4:P-PO_4 (Mg:N:P), el grado de sobresaturación, la temperatura y la presencia de iones extraños (como el

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

calcio). En el reactor piloto utilizado para la obtención de estruvita, la reacción se produce a temperatura ambiente o similar (25-30 ºC), por lo que no hay un gran consumo de energía y no es necesario añadir agua. Como materias primas se utilizaron las siguientes: digestato de purines de cerdo, sal de magnesio (normalmente $MgCl_2 \cdot 6H_2O$) y NaOH. La tecnología se ha demostrado a una escala suficientemente relevante (reactor de cristalización con una capacidad de 50 L), para que los resultados puedan ser utilizados para su posterior implementación a escala industrial. Se han obtenido rendimientos de eliminación de fósforo superiores al 95%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 8

Short title (in English):

PA8: Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency

Short summary for practitioners (in English)

This practice aims to balance the nutrients in manure (especially C:N ratio) so that a fertilizer is produced that is better useable by plants and also reduces nutrient loss through leaching. Manure is inoculated with microorganisms that have been selected to perform specific functions. The product is a liquid suspension of microorganisms based on phototropic and lactic acid bacteria and yeast in a natural environment of sugarcane molasses. These microorganisms act directly on the slurry first, and on the soil later, reducing nitrogen losses by enhancing the biodegradation of manure. When these additives under investigation are added to the manure, they are anticipated to improve the hygienic conditions in facilities (barns, coops, pens…) reducing ammonia emissions (at least 65%) and also moving carbon sources and nutrients in manure to forms easily assimilated by the plants (from ammonium to nitrate in the case of nitrogen, residual proteins converted into amino acids and solubilisation of solids and phosphorus). The microorganisms contained in this additive constitute is the ideal environment for plant growth, directly affecting the quality of the crops and the soil (the product progressively inhibits the attack of other bacteria and microorganisms that cause pathologies by having a colonizing effect on the soil).

Short title (native language):

Uso de un inóculo de microbiota y precursores enzimáticos para reducir las emisiones de amoníaco y optimizar la eficiencia del uso de nutrientes

Short summary for practitioners (native language)

Esta práctica tiene por objetivo el equilibrar los nutrientes del estiércol (especialmente la relación C:N) para que, de esta manera, se produzca un fertilizante que se aproveche mejor por las plantas y además se consiga una reducción de la pérdida de nutrientes por lixiviación. El estiércol es inoculado con microorganismos que han sido seleccionados para realizar funciones específicas. El producto es una suspensión líquida de microorganismos basada en bacterias y levaduras fototrópicas y de ácido láctico en un entorno natural de melaza de caña de azúcar. Estos microorganismos actúan directamente sobre el estiércol primero, y sobre el suelo después, reduciendo las pérdidas de nitrógeno al aumentar la biodegradación del estiércol. Se prevé que cuando estos aditivos objeto de investigación se añadan al estiércol, mejoren las condiciones higiénicas de las instalaciones (granjas, cooperativas, corrales...) reduciendo las emisiones de amoníaco (como mínimo un 65%) y también desplazando las fuentes de carbono y los nutrientes del estiércol a formas fácilmente asimilables por las plantas (de amonio a nitrato en el caso del nitrógeno, proteínas residuales convertidas en aminoácidos y solubilización de sólidos y fósforo). Los microorganismos contenidos en este aditivo constituyen el entorno ideal de

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

crecimiento de las plantas, afectando directamente a la calidad de los cultivos y del suelo (el producto inhibe progresivamente el ataque de otras bacterias y microorganismos causantes de patologías al tener un efecto colonizador sobre el suelo).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 9

Short title (in English):

PA9: A study case on the use of digestate as bio fertilizer: characterization and environmental assessment

Short summary for practitioners (in English)

In Lombardy (Italy) an anaerobic digestion (AD) plant is situated that treats 70.000 t/y waste (mainly sewage sludge) producing digestate, used as fertilizer, and biogas. An innovative stripping system reduces ammonia inhibition in the reactor while also producing ammonium sulphate, a fertilizer. Both digestate and ammonium sulphate comply to the legal limits for fertilizers. To evaluate the effect of digestate fertilization a 2 ha field test was set up. Digestate, mineral fertilizer and non-fertilized control treatment were compared in triplicate for the cultivation of wheat, rice, and corn following the principles of minimum tillage and precision agriculture. Field trials started in 2018 and will continue for three years. We observed that corn yields are statistically higher in digestate treatments, while rice yields are not statistically different between treatments. Odour emissions from digestate distribution are similar to those from mineral fertilizer, if injection in soil is used, instead of spreading. Ammonia emissions are higher in digestate treatments and lower in chemical treatments. Digestate treatments show higher cumulative emissions of N_2O and lower cumulative emissions of CH_4, compared with mineral fertilization treatments. During crop season there's a risk of nitrate leaching only after fertilizations, but nitrate concentrations at 100 cm depth are very low (< 20 mg kg^{-1}), with no differences between digestate and mineral fertilization.

Short title (native language):

Un caso di studio sull'utilizzo del digestato come bio fertilizzante: caratterizzazione e valutazione ambientale

Short summary for practitioners (native language)

L'impianto di digestione anaerobica, situato in Lombardia, tratta 70000 t/anno di rifiuti, principalmente fanghi, producendo digestato, usato come fertilizzante, e biogas. Un sistema di strippaggio innovativo riduce l'inibizione da ammoniaca nel reattore, producendo solfato ammonico; entrambi soddisfano i requisiti legali per i fertilizzanti. L'effetto della fertilizzazione con digestato è stata valutata con una prova in pieno campo (2 ha) dove vengono confrontati in triplo trattamenti con digestato, fertilizzante minerale e un controllo non fertilizzato, sulle colture di frumento, riso e mais, seguendo i principi di minima lavorazione e agricoltura di precisione. Le prove di campo, iniziate nel 2018, durano tre anni. Le rese del mais sono statisticamente maggiori nei trattamenti con digestato, mentre le rese del riso non hanno mostrato differenze significative tra i trattamenti. Le emissioni di odori allo spandimento del digestato sono risultate simili a quelle del fertilizzante minerale, nel caso in cui viene utilizzata l'iniezione nel suolo invece dello spandimento. I trattamenti con digestato mostrano maggiori emissioni cumulate di N_2O e minori emissioni cumulate di CH_4, e maggiori emissioni

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

di ammoniaca rispetto alle fertilizzazioni minerali. Durante l'anno c'è rischio di lisciviazione dei nitrati solo dopo le fertilizzazioni, ma le concentrazioni a 100 cm di profondità sono molto basse (< 20 mg kg^{-1}), senza differenze tra fertilizzazione minerale e digestato.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 10

Short title (in English):

PA10: Closing the loops at farm scale : using livestock manure to fertilize feeding crops on agroforestry plots

Short summary for practitioners (in English):

An agricultural holding in Charente-Maritime, France produces arable crops (wheat, triticale, pea, corn, and rapeseed) to breed goose livestock. The farmers decided to plant trees on an arable plot to develop an agroforestry system combining energy biomass and feeding crops while simultaneously improving animal welfare. Using its livestock effluents – slurry and manure – to fertilize the crops , this farm already engages into circular economy. However, the farmers wanted to optimize the efficiency of the effluents use, and decrease their synthetic fertilizer input. The Chamber of agriculture proposed a demonstration action on the agroforestry plot to analyze the effluents behavior as fertilizers and to assess carbon storage and soil fertility in 2019-2021, using soil analysis, remote sensing and modeling tools. The feeding crops are commonly fertilized using synthetic Nitrogen fertilizer. In the first year (2019), this was partially substituted by livestock slurry : 15% of the crop requirement was provided by soil stock nitrogen, 20% from animal manure and 65% by synthetic fertilizers. Considering climatic conditions it is too early to make firm conclusions on comparison of nutrient efficiency from effluents against that of mineral fertilizer. In the following growing seasons, we aim to systematically increase the use of biobased fertilizer sources and reduce the dependency on mineral fertilizers. As results of this demonstration, it is expected to draft possible scenarios to increase the substitution of synthetic fertilizers by farm effluents and assess the increases of soil fertility and carbon storage in this agroforestry system. When the results are positive, the farmers will extend the agroforestry system to a wider area.

Short title (native language):

Fermer les cycles élémentaires à la ferme : fertiliser les cultures fourragères par les effluents d'élevage en parcelle agroforestière.

Short summary for practitioners (native language):

Une exploitation agricole de Charente-Maritime produit les cultures (blé, triticale, pois, maïs et colza) pour alimenter son élevage d'oies. Les agriculteurs ont décidé d'implanter des arbres sur une parcelle pour installer un système agroforestier combinant production de biomasse énergétique, cultures alimentaires et amélioration du bien être animal. Utilisant ses effluents d'élevage pour fertiliser les cultures, cette ferme propose un haut niveau d'économie circulaire. Mais les agriculteurs veulent optimiser l'utilisation des effluents d'élevage et ainsi diminuer les engrais synthétiques ou d'extraction en assurant la circulation des nutriments NP et en assurant un haut niveau de captation du carbone pour une bonne production agroforestière. La Chambre d'agriculture a proposé de conduire une démonstration de suivi des effluents sur la parcelle agroforestière pour évaluer le stockage de carbone et la fertilité du sol sur la période 2019-2021, à partir de l'analyse du sol et à l'aide d'outils de télédétection

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

et de modélisation. Les cultures sont habituellement fertilisées avec des engrais synthétiques. Pendant la première année (2019), la substitution partielle par du lisier fournit 20% des besoins en N contre 15% par le sol et 65% par les engrais synthétiques. Actuellement, il n'y a pas le recul nécessaire pour comparer l'efficacité des effluents à celle des engrais minéraux, sachant qu'elle dépend fortement des conditions climatiques. Par la suite, nous visons à augmenter la substitution par les effluents agricoles avec évaluation de la fertilité des sols et du stockage du carbone. En cas de retour positif, les agriculteurs pourraient étendre la solution agroforestière à une plus grande surface de leur exploitation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 11

Short title (in English):

PA11: Substituting mineral inputs with organic inputs in organic viticulture

Short summary for practitioners (in English)

A farm in Charente Maritime, France, combines field crops with a vineyard. Crop production is done through organic farming for the past 5 years, whereas the vineyard already for ten years. With this progressive change into organic farming, the farmers had to change their fertilization practices towards organic fertilizers. However, an important problem to face in organic farming is the lower efficiency in NP inputs, because of the more unpredictable behavior of organic fertilizers without appropriate monitoring. The farm cultivates about ten species including Rapeseed, Hemp, Sunflower and Camelina for oil. After treating the oilseed crops, the farm gets oil-cake as residue. Until now the oil-cakes are used as livestock feed for a neighboring farm, but the farmers would like to recover their residues. To decide whether the oil-cake could be used as fertilizer, or soil enhancer with biostimulating effects for the vineyard, they need to monitor the synchronization between NP release from residues and the grapevine uptake and optimize the balance between C storage and organic fertility in the soil of grapevine plots. A demonstration essay has been designed to follow up and assess the fertilizing efficiency of the farm residues alone or combined with a commercial organic fertilizer on the plot with vineyard, from 2019-2021. With the characterizations of the oil-cake and the plot soil, the grapevine development will be monitored with a manual sensor and remote sensing to assess the biomass and nitrogen status, and will be explained with the properties of the organic inputs. The results provided by this demonstration should provide key information to decide on the best way for recycling their residue and whether this is the right way to go.

Short title (native language): La substitution des intrants minéraux par les intrants organiques en viticulture biologique

Short summary for practitioners (native language)

Une ferme en Charente Maritime associe grandes cultures et viticulture. Avec le passage progressif à l'agriculture biologique, vignoble puis grandes cultures, les agriculteurs ont dû changer leurs pratiques de fertilisation et doivent utiliser des engrais biologiques. La moindre efficacité des apports en NP, du fait du comportement des fertilisants organiques plus difficile à évaluer, est un enjeu. La ferme cultive une dizaine d'espèces en grandes cultures dont le colza, le chanvre, le tournesol et la cameline pour l'huile. Après l'extraction de l'huile, la ferme recycle les tourteaux comme aliments pour bétail donnés à une exploitation voisine. Les agriculteurs s'interrogent sur le meilleur moyen de valoriser leurs résidus. Pour décider l'utilisation du tourteau comme fertilisant ou amendement pour la vigne, ils doivent vérifier la bonne synchronisation entre la libération de nutriments des résidus et l'absorption par la vigne, et optimiser l'équilibre entre le stockage de C et la fertilité organique dans le sol des parcelles de vigne. Un essai de démonstration a été conçu pour suivre et évaluer l'efficacité fertilisante des résidus de ferme seuls ou combinés avec un engrais organique commercial sur la parcelle avec vignoble, de

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

2019 à 2021. Avec les caractérisations des tourteaux et du sol de la parcelle, le développement de la vigne sera suivi par capteur manuel et télédétection pour évaluer la situation de la biomasse et de l'azote. Il sera expliqué par les propriétés des apports organiques. Les résultats de cette démonstration d'essai devraient fournir aux agriculteurs les informations clés pour décider de la meilleure façon de recycler leurs résidus et, si le recyclage agronomique est le bon moyen.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 12

Short title (in English):

PA12: Partial substitution of mineral fertilizers by animal manures in an apple orchard

Short summary for practitioners (in English)

The excessive use of mineral fertilizers seen in the last few decades has contributed to an increase in environmental impacts, such as water contamination, soil erosion and resource depletion. To maintain crop productivity high but its impacts low, it is vital to promote the recycling of nutrients and to increase resource use efficiency. The present work's aim is the substitution of the conventional mineral fertilizers with manures and slurries, thus taking avail of livestock production wastes and hopefully maintain crop productivity but with less impacts. As such, it is important to study the effects of organic (manures and slurries) versus mineral fertilization. In our trials, cattle manure, poultry manure, cattle slurry, and acidified cattle slurry were applied to soil in an apple orchard, with the purpose of evaluating fruit production and quality, greenhouse gas (GHG) emissions and soil nutrient content. Regarding fruit production, there were no significant differences between the mineral and the organic treatments, indicating that the organic materials did not injure crop productivity as one would expect due to their characteristic slow mineralization rate, however, leaf analysis has shown that the organic treatments presented higher content of phosphorus, potassium, and boron, indicating that the plants were able to obtain nutrients from the manures and slurries. However, the organic treatments produced more GHG, although it is worthy to note that acidified cattle slurry has significantly reduced CH4 emissions when compared to raw cattle slurry, hence reducing the environmental impacts associated with slurry application. More results are expected, as the trials are still on-going, nonetheless the outcomes seem promising. Replacement of mineral fertilizer by manure in orchards fertilization is an excellent tool to improve the soil quality but also to decrease the carbon footprint of apple production. Furthermore, the use of manure might be beneficial for maintenance of soil cover.

Short title (native language):

Substituição parcial da fertilização mineral por estrumes e chorumes num pomar de macieira

Short summary for practitioners (native language)

O uso excessivo de fertilizantes minerais visto nas últimas décadas tem contribuído para o aumento dos impactos ambientais, como a contaminação de água, erosão do solo e esgotamento de recursos. Para manter a produtividade alta, mas os impactos baixos, é vital promover a reciclagem de nutrientes e aumentar a eficiência do uso de recursos. O objetivo do presente trabalho é a substituição dos fertilizantes minerais convencionais por estrumes e chorumes na fertilização de pomares de macieira, aproveitando-se dessa forma os resíduos da produção pecuária mantendo-se a produtividade da cultura e reduzindo os impactos ambientais associados. Como tal, é importante estudar os efeitos da fertilização orgânica (estrumes e chorumes) versus mineral. Os nossos ensaios utilizarão estrume bovino, estrume de aves, chorume bovino e chorume bovino acidificado, com o objetivo de avaliar a

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

produção e o desempenho da cultura, as emissões de gases com efeito estufa (GEE) e o teor de nutrientes no solo. Em relação à produção de frutos, não houve alterações significativas entre tratamentos, indicando que os materiais orgânicos não prejudicaram a produtividade da cultura como seria de esperar devido à característica taxa de mineralização lenta, no entanto, a análise foliar mostrou que os tratamentos orgânicos apresentaram maior conteúdo de fósforo, potássio e boro, indicando que as plantas foram capazes de utilizar os nutrientes nestes tratamentos. No entanto, os tratamentos orgânicos produziram mais GEE, embora o chorume bovino acidificado tenha diminuído significativamente as emissões de CH4 quando comparado ao chorume bovino bruto, reduzindo assim os impactos ambientais associados à aplicação de chorumes. Esperam-se mais resultados, pois os ensaios ainda estão a decorrer, mas os primeiros resultados parecem promissores. A substituição de fertilizantes minerais por estrume ou chorume na fertilização de pomares é uma excelente ferramenta para melhorar a qualidade do solo, mas também para diminuir a pegada de carbono da produção de maçã. Além disso, o uso de estrumes e chorumes pode ser benéfico para a manutenção do coberto vegetal na entrelinha.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 13

Short title (in English):

PA13: Enhanced manure recycling by producing manure-based fertilizers

Short summary for practitioners (in English)

The production of a manure-based fertilizer will proportionate a more sustainable agriculture practice through the valorisation of animal manure in a circular economy. Hence by adding an organic material to the soil the carbon soil reserve should increase and thereby improve its fertility and productivity. The production of a manure-based fertilizer will allow a better control of the nutrients flow, since it will ensure a decrease in the nutrient losses associated with the raw manures, such as ammonia emissions or nitrate leaching. Also, one of the difficulties in applying manure is the nutrients' concentration that are unbalanced for the crop's necessities, so in that case, this production aims to produce a fertilizer based on the mixture of manures, treated or not, that will have a known ratio of N:P. In that line, two scenarios are possible, one at farm scale where the farm manure can be amended with a small amount of mineral fertilizer to achieve the desired N:P ratios, and a second scenario where, at a central plant, different manures will be blended between them also to reach the intended N:P ratios. In both scenarios, the intention is to use mineral fertilizers as a complement and not as the main nutrients sources. The manure-based fertilizer will allow to close the nutrient cycle since the solution proposed here intended to reduce the known environmental impacts of manure application to the soil and, by reducing nutrients losses, the agronomic results should be comparable to the mineral fertilizers. The results obtained in this project showed at farm scale, it is possible to improve the agronomic value of manure by using some simple treatment as separation or by using some additives. It is to believe that such improvement might contribute to a wider use of manure as substitute of mineral fertilizers.

Short title (native language):

Produção de fertizante orgânico com base em efluentes Pecuários

Short summary for practitioners (native language)

A produção de fertilizante orgânico com base em efluentes pecuários, irá proporcionar práticas agrícolas mais sustentáveis, pela valorização de efluentes pecuários numa filosofia de economia circular. Não obstante, a adição de material orgânico ao solo irá aumentar a sua reserva de carbono e por conseguinte melhorar a fertilidade e produtividade do mesmo. A produção do fertilizante orgânico irá permitir um melhor controlo dos fluxos de nutrientes, visto garantir uma diminuta perda de nutrientes associada aos efluentes em bruto, tais como as emissões de amoníaco ou a lixivição de nitratos. Por outro lado, uma das dificuldades em aplicar efluentes pecuários é a sua concentração de nutrientes, que é desproporcional face às necessidades das culturas, pelo que este trabalho terá o intuito de produzir um fertilizante através da mistura de efluentes pecuários, com ou sem tratamento, que terão um rácio de N:P conhecido. Neste sentido, criaram-se dois cenários, o primeiro atuando ao nível da exploração onde ao efluente da mesma será adicionada uma pequena quantidade de adubo para perfazer os rácios requeridos, enquanto no segundo criou-se uma central de processamento onde ocorrerá a mistura dos efluentes entre si para obter igualmente os referidos rácios. Em ambos os

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

cenários, a intenção é que a fertilização mineral passe a ser um complemento. A produção do fertilizante orgânico irá permitir fechar o ciclo de nutrientes visto que a solução proposta pertende reduzir os impactos ambientes associados à aplicação de efluentes em bruto e pela redução da perda de nutrientes é expetável uma performance agronómica similar à aplicação de fertilizantes minerais.

Os resultados obtidos neste projeto mostraram que é possível, à escala da exploração, melhorar o valor agronômico dos estrumes e chorumes usando alguns tratamentos simples como a separação ou usando alguns aditivos. Acredita-se que tal melhoria possa contribuir para uma utilização mais ampla dos estrumes e chorumes como substitutos de fertilizantes minerais.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 14

Short title (in English):

PA14: Use of digestate in orchards

Short summary for practitioners (in English)

The Nutri2Cycle project will assess the current Nitrogen (N), Phosphorus (P) and Carbon (C) flows looking into existing management techniques in different farms across Europe and analysing their related environmental problems. One of such technologies is the application of digestate in orchards. If taking into consideration that the vast majority of Croatian farmers don't apply digestate in agricultural production, one could conclude that digestate application can be considered as an innovative solution. Application of digestate in large scale orchards may have been applied across EU already, but it is considered to be an innovative management solution in Croatia. Furthermore, when digestate is applied it is usually for the energy crop production and not in long-term plantations. The underlying working principle refers to the application of digestate in raspberry plantation in the beginning of the project. In the phase of soil preparation, a combination of $Ca(OH)_2$ in concentration of 1,00 t/ha, thick fraction of digestate in concentration of 50,00 t/ha and cattle manure in concentration of 33,00 t/ha was used. Also, next to organic fertilizers, 30 grams/plant of mineral fertilizer (NPK 7-20-30) was also applied. When investigating existing research databases, there were no specific research found on application of digestate in raspberry plantation. Use of digestate contributes to the Nitrogen and Carbon cycles in agriculture. It can also increase soil biodiversity, while reducing erosion, leaching and water pollution Numerous research findings indicate that digestate from agricultural biogas plants cannot only be a good fertilizer but also an effective mean to close the carbon cycle in the soil for a more sustainable agriculture. To conclude, digestate in Croatia is often neglected in application. When deciding, farmers should take into account important benefits that digestate has for crops, such as presence of high amounts of easily accessible plant nutrients, improved physical structure of soil, reduced ammonia emissions, and the appearance of unpleasant odours. Considering these aspects, farmers now have a new and significant role in society, as both, crop and energy producers and waste processors.

Short title (native language):

Primjena digestata u voćarstvu

Short summary for practitioners (native language)

Projekt Nutri2Cycle će osigurati važna dostignuća za održivo i učinkovito upravljanje prirodnim resursima. Također, predmetni projekt analizira trenutne tokove dušika (N), fosfora (P) i ugljika (C), odnosno postojeće tehnologije njihovog upravljanja na poljoprivrednim gospodarstvima. Jedna od takvih tehnologija je i primjena digestata u voćarstvu. Ako se uzme u obzir da velika većina hrvatskih poljoprivrednika ne primjenjuje digestat u poljoprivrednoj proizvodnji, moglo bi se zaključiti da se primjena digestata smatra inovativnim rješenjem u poljoprivredi. Primjena digestata u voćnjacima

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

velikih površina možda je već i zastupljena u cijeloj EU, ali u Hrvatskoj se smatra inovativnim rješenjem. Nadalje, kada se primjenjuje digestat, njegova primjena je učestalija u proizvodnji energetskih usjeva, za razliku od primjene u dugogodišnjim nasadima. Temeljni princip rada odnosi se na primjenu digestata u nasadu malina na početku projekta. U fazi pripreme tla kombinacija $Ca(OH)_2$ u koncentraciji 1,00 t/ha, kruti digestat u koncentraciji 50,00 t/ha i goveđi gnoj u koncentraciji 33,00 t/ha je korišten. Također, uz organska gnojiva primijenjeno je i 30 grama/biljci mineralnog gnojiva (NPK 7-20-30). Tijekom istraživanja postojećih baza podataka, nisu pronađena značajna istraživanja o samoj primjeni digestata u voćarstvu. Korištenje digestata doprinosi ciklusima dušika i ugljika u poljoprivredi. Također, primjena digestata doprinosi povećanju biološke raznolikosti tla, istovremeno smanjujući eroziju, ispiranje i zagađenje vode. Nadalje, istraživanja pokazuju da digestat iz poljoprivrednih bioplinskih postrojenja može biti i gnojivo, ali imati i značaj u zatvaranju ciklusa ugljika u tlu radi održivije poljoprivrede. Može se zaključiti da je digestat u Hrvatskoj često zanemaren u primjeni. Poljoprivrednici bi trebali razmotriti najvažnije prednosti, koje uključuju prisutnost velikih količina lako dostupnih biljnih hranjivih tvari, poboljšanu fizičku strukturu tla, smanjenu emisiju amonijaka i pojavu neugodnih mirisa. Uzimajući u obzir gore navedeno, poljoprivrednici stječu novu i važnu ulogu u društvu, kao proizvođači energije i prerađivači otpada.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 15

Short title (in English):

PA15*: Lemna minor* cultivation for treating swine manure and providing micronutrients for animal feed

Short summary for practitioners (in English)

Treatment and nutrient recovery of waste streams have an essential role in improving the sustainability of conventional agriculture. *Lemna minor*, small floating-flowering aquatic plants known as duckweed, has been shown to grow on wastewaters and subsequently produce a protein-rich feed ingredient suitable for pig production, offering a possible solution for addressing both the protein scarcity and local nutrient abundancy. In this study, the potential of *Lemna minor* to valorise agricultural wastewater into a protein-rich feed component to meet the growing demand for animal feed protein and reduce the excess of nutrients in certain European regions was investigated. Three pilot-scale systems were fed with a mixture of the liquid fraction and the biological effluent of a swine manure treatment system diluted with rainwater in order that the weekly N and P addition was equal to the N and P removal by the system. The study shows that a duckweed lagoon can be used as an extra polishing step after swine manure treatment, converting the manure into dischargeable water instead of spreading it on arable land. Based on the N and P removal, it is estimated that one hectare of duckweed can remove the residual N and P of the biological effluent produced by 2805 swines. However, the side streams contain also K, Cl, S, Ca, Mg, and Na. It was found that these are inadequately removed from the system and will accumulate over time. By extrapolation, it was found that after 9 years K will be the first element to reach toxic concentrations for duckweed. This means that an operator should replenish the growing medium before this time. Furthermore, it should be avoided that potential harmful elements like the heavy metals As, Cd, and Pb would accumulate over time in the growing medium and subsequently taken up by the plant reaching toxic concentrations for animal consumption. It was observed that As, Cd, and Pb content were below the limits of the feed Directive 2002/32/EC in the duckweed grown on the tested medium are the elements even decreased over time. This is evidence for policy makers to consider the use of agricultural side streams like the biological effluent of the pig manure treatment system as a nutrient source for duckweed cultivation which is intended for animal consumption, if other safety risks are also validated in a similar way. In contrast, the plant is even a source of Mn, Zn, and Fe which are beneficial elements for swine's metabolisms.

Short title (native language):

De kweek van *Lemna minor* om varkensmest te verwerken en te dienen als bron van micronutriënten in varkensvoeder

Short summary for practitioners (native language)

Het potentieel van Lemna minor om landbouwkundige zijstromen in eiwitrijk voeder om te zetten werd onderzocht om tegemoet te komen aan de groeiende vraag naar eiwitrijke diervoeders en het overschot aan nutriënten in sommige regio's in Europa te verwerken. Daarvoor werden er drie

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

opstellingen gevoed met een verdund mengsel van vloeibare fractie en biologisch effluent van varkensmest zodat de wekelijkse toevoeging van N en P gelijk staat aan de verwijderingscapaciteit dat het systeem heeft. De studie toont aan dat een eendenkroosvijver gebruikt kan worden als een laatste omzettingstap van biologisch effluent tot loosbaar water, waardoor het niet meer hoeft uitgereden worden op landbouwgrond. Het wordt geschat dat een hectare eendenkroos de mest van 2805 varkens kan verwerken. Echter, naast N en P bevatten de stromen ook K, Cl, S, Ca, Mg, en Na. Bij een continue toediening werd vastgesteld dat de verwijderingscapaciteit van het systeem lager is dan de toediening, waardoor de elementen accumuleren na verloop van tijd. K is het eerste element die concentraties zal bereiken die hoger zijn dan de toxische grens voor eendenkroosgroei. Een kweker zal dus minstens om de 9 jaar het water moeten verversen. Bovendien moet vermeden worden dat toxische elementen zoals As, Cd, en Pb accumuleren tot toxische concentraties. In de studie werd geobserveerd dat deze elementen dalen over tijd en steeds onder de voorgeschreven limieten staan (uit Europese richtlijn 2002/32/EC). Dit kan ondersteunend bewijs zijn voor beleidsmakers om het gebruik van eendenkroos in diervoeders toe te laten nadat ze bemest zijn met reststromen uit de varkensmestverwerking. Dit als ook aanwijzingen zijn dat er geen andere gezondheidsrisico's bestaan die hier niet werden onderzocht. Bovendien blijkt dat het eendenkroos ook een bron is van Mn, Zn, en Fe, waardoor het gunstig kan zijn voor het metabolisme van het varken.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 16

Short title (in English):

PA16: Poultry and chicken manure management - practical considerations in Polish conditions

Short summary for practitioners (in English)

Management of poultry and chicken manure is a challenge not only in Poland but globally. Due to the concentration of large poultry farms, it is more important to use such a management methods that will reduce the negative impact on the environment, and at the same time will be consistent with the principles of circular economy and economically justified. It is also important to take into account the carbon footprint and legislation in force in a given country, as well as the European Green Deal strategy. Currently, poultry and chicken manure are most often used as an organic fertilizer in agriculture. However, due to the environmental nuisance and periodicity of application, new technologies are considered as a source of energy and fertilizers. The most advanced methods of energy recovery include methane fermentation, but in Poland manure or chicken manure is used only in a few agricultural biogas plants, only in the process of co-fermentation with other substrates. This is due to high investment costs and the optimization process that requires specialist knowledge. More widespread is drying and granulating of chicken / poultry manure itself or prior mixing with various other substrates (dolomite, opoka-rock, coal), which are placed on the market after being certified as eco-fertilizers. The most important criterion for selecting a technology for farmers is the cost of the investment and the benefits that would be obtained from the selected technology. Additional important factors in the final choice are incentives and technical support, environmental regulations and level of education. The size of the farm is also important as there must be consistency between the quantity of the waste stream and the processing technology. On the other hand, external investors take into account the net profit as the most important criterion, and for the local government an important aspect is the acceptance or not of the local community. Poultry farm owners who plan to handle and manage poultry manure onsite can use the help from specilized consulting companies or scientific consultants who can help with the selection of a poultry manure processing technology and the development of a case-specific solution.

Short title (native language):

Zagospodarowanie pomiotu i obornika kurzego – uwarunkowania praktyczne w warunkach polskich

Short summary for practitioners (native language)

Zagospodarowanie pomiotu i obornika kurzego stanowi wyzwanie nie tylko w Polsce ale i na świece. Z uwagi na koncentrację dużych ferm drobiarskich coraz istotniejszy jest taki sposób zagospodarowania, który ograniczy negatywny wpływ na środowisko, a jednocześnie będzie zgodny z zasadami GOZ i ekonomicznie uzasadniony. Nie bez znaczenia jest także uwzględnienie śladu węglowego i prawodawstwa obowiązującego w danym kraju a także strategii Europejskiego Zielonego Ładu. Obecnie najczęściej obornik i pomiot wykorzystywane są jako nawóz organiczny w rolnictwie. Jednak ze względu na uciążliwość środowiskową i okresowość stosowania, rozpatrywane są nowe technologie jako źródło

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

energii oraz nawozów. Do najbardziej zaawansowanych metod odzysku energii należy fermentacja metanowa, jednak w Polsce obornik czy pomiot kurzy wykorzystywany jest zaledwie w kilku biogazowaniach rolniczych, wyłącznie w procesie kofermentacji z innymi substratami.

Związane jest to z wysokimi kosztami inwestycyjnymi i wymagającym specjalistycznej wiedzy procesem optymalizacji. Bardziej rozpowszechnione jest suszenie i granulowanie samego obornika/pomiotu lub uprzednie mieszanie z różnymi innymi substratami (dolomit, opoka, węgiel), które po uzyskaniu certyfikatu eko-nawozów są wprowadzane na rynek. Najważniejszym kryterium wyboru technologii dla właścicieli ferm jest koszt inwestycji oraz korzyści, jakie uzyskaliby dzięki wybranej technologii. Ważnymi czynnikami ostatecznego wyboru są także zachęty i wsparcie techniczne, przepisy środowiskowe i poziom wykształcenia. Ważna jest także wielkość gospodarstwa, ponieważ musi istnieć spójność między ilością strumienia odpadów a technologią przetwarzania. Z kolei zewnętrzni inwestorzy jako najważniejsze kryterium uwzględniają zysk netto, a dla samorządu lokalnego ważnym aspektem jest akceptacja lub nie miejscowej społeczności. Właściciele ferm kurzych, którzy chcą we własnym zakresie zagospodarowywać pomiot kurzy mogą zwrócić się do wyspecjalizowanych firm doradczych bądź konsultantów naukowych, którzy z kolei pomogą w wyborze odpowiedniej technologii i opracowaniu rozwiązania dla danego przypadku.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 17

Short title (in English):

PA17: Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to theenvironment – 2nd year

Short summary for practitioners (in English)

Large surpluses of on-farm nitrogen (N) and phosphorus (P) are processed or exported out of Flanders while tonnes of synthetic N-fertilisers are purchased and used for crop production. The use of recycling- derived fertilisers (RDFs) from manure can counter this situation. Currently, RDFs derived from animal manure still need to comply with the legal application constraints of animal manure and are thus not often used. That is why five RDFs (ammonium nitrate, ammonium sulphate, digestate from co-digestion of pig manure, liquid fraction of digestate and pig urine) are compared with mineral fertiliser CAN, pig manure and a blank treatment in a 3-year field trial focusing on short term N-effects of the RDFs. The main goal of the trial is to establish a clear relationship between the amount of N applied by RDF and dry matter production for each applied RDF. During the second year of the field trial (crop: spinach), weather conditions had a significant impact: the trial period was extremely dry, with only 12 l/m² of rain received between sowing and harvest. Therefore water shortage was an important factor influencing the growth of spinach. Hence, local differences in soil fertility appeared causing N availability as no longer the only decisive factor for crop growth and causing extra variability in the field trial, parallelly with a sandstorm that damaged many young plants. Therefore, no differences in fresh and dry yield were observed between RDFs, except ammonium nitrate which had significantly lower yield. This is probably also due to soil treatment because the applied N via ammonium nitrate had to be directly in contact with the root zone in harmful dry conditions. Residual nitrate was lower than legal limits for all RDFs except pig urine at 70% N dose.

Short title (native language):

Korte stikstof termijneffect van herwonnen meststoffen met focus op gewasopbrengst en stikstofverliezen naar het milieu - 2e jaar

Short summary for practitioners (native language)

Het mestoverschot in Vlaanderen wordt verwerkt en geëxporteerd, terwijl kunstmest wordt aangekocht om in de gewasbehoefte te voorzien. Nochtans kan het gebruik van herwonnen meststoffen dit oplossen. Echter moeten deze voldoen aan de wettelijke toepassingsvereisten van dierlijke mest waardoor het gebruik laag is. Daarom worden de korte stikstof termijneffecten van vijf herwonnen meststoffen (ammoniumnitraat, -sulfaat, digestaat, dunne fractie van digestaat en varkensurine) vergeleken met KAS kunstmest, varkensmest en een blanco behandeling in een driejarige veldproef. Het doel van de proef is om een verband te leggen tussen de hoeveelheid N die wordt aangebracht en de drogestofproductie. Tijdens het tweede jaar van de velproef (gewas: spinazie) hadden de weersomstandigheden een grote invloed: de proefperiode was extreem droog,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

met slechts 12 l/m² regen tussen zaaien en oogsten. Watertekort was daarom een belangrijke factor. Dit veroorzaakte lokale verschillen in bodemvruchtbaarheid waardoor N-beschikbaarheid niet langer de bepalende factor was voor de gewasgroei. Bovendien was er door de droogte en een zandstorm extra variabiliteit. Er werden daarom geen verschillen in verse en droge opbrengst waargenomen tussen de herwonnen meststoffen, behalve een significant lagere opbrengst bij ammoniumnitraat. Dit effect heeft wellicht te maken met de bodembewerkingen, aangezien de toegediende N via ammoniumnitraat reeds van bij het begin van de teelt in de bewortelde zone aanwezig moet zijn. Hierdoor kwamen de kiemplantjes direct in contact met de meststoffen in stresserende, droge omstandigheden. Het nitraatresidu was voor alle meststoffen lager dan het wettelijk maximum, behalve voor varkensurine 70%.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 18

Short title (in English):

PA18: Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil

Short summary for practitioners (in English):

Due to the increase of the population and the improvement of life quality for large groups of people worldwide, the food need and the production of wastes is increasing consequently. Higher food production will require a higher quantity of fertilizers, while waste disposal (mainly sewage sludge) can be expensive, energy consuming and environmentally hazardous. The system encompasses a plant performing anaerobic digestion on sewage sludge. Anaerobic digestion is a biological process, conducted without air that stabilizes the substrate, makes the nutrients more available for plants, and increases the product's health safety while producing biogas. The digestate can partly substitute chemical fertilizers in a very efficient way. Moreover, this plant has a “stripping system” that can extract ammonia to increase the plant's digestion efficiency and produce ammonium sulphate, which can be used as valuable fertilizer or sold for industrial uses. Results are not complete yet, because tests are still in progress, but we can already share some comments:

I. In a full-scale field experiment, rice yields were similar using chemical fertilizers vs digestate + ammonium sulphate, showing the excellent quality of this solution for fertilization (experiment now running for two years out of three).
II. Analyses on rice grain showed similar composition for chemical fertilizers and for digestate + ammonium sulphate fertilization.
III. Using digestate + ammonium sulphate, we expect an increase of soil quality, intended as organic matter quantity and stability.
IV. Nitrate leaching in digestate + ammonium sulphate fertilization resulted very low, similar with chemical treatment and the untreated.

The Digestate + Ammonium sulphate combination is a suitable fertilizer, safe, and with performance substantially equal to traditional chemical fertilizers. Nevertheless, such equivalent performance cannot be reached if other practices are not assured in its production and use (i.e. digestate highly stabilized and injected in soil). Besides, the parallel electric energy production (through biogas combustion) and the safe sewage sludge disposal make this technology very efficient. Finally, based on the provisional data, it has a positive effect on soil in the long run, increasing the amount and stability of organic matter, while the concentrations of pollutants (both organic and inorganic) are similar to that of a traditional fertilized field.

Short title (native language): Utilizzo di digestato, agricoltura di precisione e minima lavorazione per aumentare la qualità del suolo e lo stoccaggio di sostanza organica

Short summary for practitioners (native language):

A causa dell'aumento della popolazione e del miglioramento della qualità della vita per alcune fasce di popolazione, il fabbisogno alimentare e la produzione di rifiuti sono in aumento. Una maggiore produzione alimentare richiederà una maggiore quantità di fertilizzanti, mentre lo smaltimento dei

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

rifiuti (principalmente fanghi di depurazione) è costoso, richiede grandi quantità di energia ed è pericoloso per l'ambiente. L'impianto in questione processa fanghi di depurazione tramite digestione anaerobica. Quest'ultima è un processo biologico, condotto in assenza di aria, che stabilizza il substrato, rende più disponibili i nutrienti per le piante e aumenta la sicurezza sanitaria del prodotto, producendo biogas. Il digestato così prodotto può sostituire in parte i fertilizzanti chimici in modo molto efficiente. Inoltre, questo impianto dispone di un "sistema di strippaggio" in grado di estrarre ammoniaca, così da aumentare l'efficienza dell'impianto e produrre solfato di ammonio, che viene utilizzato come fertilizzante o può essere venduto per usi industriali. Visto che i lavori sono ancora in corso i risultati non sono definitivi, ma possiamo già condividere alcuni commenti:

I. In un esperimento in pieno campo, le rese del riso sono state simili utilizzando fertilizzanti chimici e digestato + solfato di ammonio, a dimostrazione dell'eccellente qualità di questa soluzione per la fertilizzazione (esperimento ora in corso da due anni su tre).

II. Le analisi sul chicco di riso hanno mostrato una composizione simile per la fertilizzazione chimica e per digestato + solfato di ammonio.

III. Utilizzando digestato + solfato di ammonio ci aspettiamo un miglioramento della qualità del suolo, inteso come quantità e stabilità di sostanza organica.

IV. La lisciviazione dei nitrati nella fertilizzazione con digestato + solfato di ammonio è risultata molto bassa, simile al trattamento chimico e al non trattato.

La combinazione digestato + solfato ammonico è un fertilizzante idoneo, sicuro e con prestazioni sostanzialmente pari ai tradizionali fertilizzanti chimici. Tuttavia, tali prestazioni positive non possono essere raggiunte se non sono assicurate altre pratiche nella sua produzione e utilizzo (es. digestato altamente stabilizzato e iniettato nel suolo). Inoltre, la produzione elettrica (attraverso la combustione del biogas) e lo smaltimento sicuro dei fanghi di depurazione rendono questa tecnologia molto efficiente. Infine, dai dati provvisori, ha un effetto positivo sul suolo nel lungo periodo, aumentando la quantità e la stabilità della sostanza organica, mentre la concentrazione degli inquinanti (sia organici sia inorganici) è simile ad un campo fertilizzato tradizionalmente.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 19

Short title (in English):

PA19: Producing bio-fertilisers from pig manure through different separations stages

Short summary for practitioners (in English)

Intensive livestock activity in Lombardy (northern Italy) and in other regions in Europe (like Denmark; Catalonia, Spain; Flanders, Belgium; Netherlands) is causing several environmental issues. The nitrates directive limits the amount of manure that can be used in fields (depending on if the area is considered vulnerable or not). The possibility to export some fractions of the effluent can increase the number of livestock heads without jeopardising the environment. The plant separates the effluent in a solid fraction, which will be composted and a liquid fraction. The latter is further separate thanks to reverse osmosis (super tight filtrations) in clean water and a concentrate that can be exported from the farm as RENURE (it could be considered a chemical fertiliser instead of livestock effluent). Results are not complete yet because tests are still in progress, but we can already share some comments:

I. "Clean" water, more than half of the input volume, fit all the parameters to be disposed in superficial water bodies (rivers or lakes) or used for irrigation,
II. about one-sixth of the input volume is recovered as solid fraction that can be composted
III. The liquid concentrate has high concentration of ready-to-use nutrients for plants.

Moreover, a real scale field experiment is set (on corn) to demonstrate that fertilisation with concentrate is AT LEAST as good as a chemical fertilisation (urea).

Short title (native language):

Produzione di bio fertilizzanti da effluenti suinicoli attraverso successive separazioni

Short summary for practitioners (native language)

L'intensa attività zootecnica in Lombardia e in altre regioni d'Europa (come Danimarca, Catalogna, Spagna, Belgio, Paesi Bassi) sta causando diversi problemi ambientali. La direttiva nitrati pone un limite alla quantità di letame che può essere messo in campo (a seconda che l'area sia considerata vulnerabile o meno). La possibilità di esportare alcune frazioni dell'effluente può aumentare il numero di capi di bestiame senza compromettere l'ambiente. L'impianto separa le deiezioni in una frazione solida, che verrà compostata, e in una frazione liquida. Quest'ultimo è ulteriormente separato grazie all'osmosi inversa (una filtrazione estremamente fine) in acqua pulita e un concentrato che può essere esportato dall'azienda come RENURE (può essere considerato un fertilizzante chimico e non come effluenti zootecnici). I risultati non sono ancora completi perché i test sono ancora in corso, ma possiamo già condividere alcuni commenti:

I. L'acqua "pulita", più della metà del volume in ingresso, soddisfa tutti i parametri per essere smaltita in corpi idrici superficiali (fiumi o laghi) o utilizzata per l'irrigazione.
II. Circa un sesto del volume in ingresso viene recuperato come frazione solida compostabile.
III. Il concentrato ha un'alta concentrazione di nutrienti pronti all'uso per le piante.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Inoltre, è stato impostato un esperimento di campo in scala reale (sul mais) per dimostrare che la fertilizzazione con concentrato è ALMENO efficace quanto la fertilizzazione chimica (urea).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 20

Short title (in English):

PA20: Are consumers willing to pay a premium price for sustainable food?

Short summary for practitioners (in English)

Understanding consumer behaviour, perception and acceptance of eco-friendly and sustainable food products is one of the key objectives for the Nutri2Cycle project with the aim of bridging the current environmental informational gap between producers and consumers. As a first step towards achieving this goal, techniques of meta-analysis were applied to studies on the relationship between sustainable agricultural products and consumers' willingness to pay (WTP). The data obtained from over 100 papers screened in the analysis showed that the percentage difference in the WTP estimated ranged from 2% to 92%. The overall WTP valuation was calculated as 33%, that is, consumers are willing to pay about a 33% more for sustainable attributes in food products. This WTP depended significantly on variations of the consumers' region (the highest WTP was located in Asia, 65%) as well as the food categories (cereal & bread provided the highest WTP, 60%). Moreover, the results showed the presence of different sustainable claims was not a significant factor and it did not influence the WTP significantly which means that consumers have knowledge about what sustainable food product is but should become more familiar with them to learn to distinguish between the different sustainable claims and their meanings. There are currently a wide range of Ecolabels in the market, with significant differences in scope, indicators, verification processes or claims affecting the overall effectivity of Ecolabels. The farmers can indeed benefit from striving towards a label - as consumers are willing to pay more – however, the labelling landscape is too scattered. Therefore, unification of the Ecolabelling schemes is required and the European ecolabelling landscape need a continuous updating that allows an easy decision-making process for consumers and stakeholders involved.

Short title (native language):

Están los consumidores dispuestos a pagar más por los alimentos sostenibles?

Short summary for practitioners (native language)

Comprender cuál es la percepción del consumidor por los alimentos etiquetados como sostenibles y/o respetuosos con el medio ambiente es uno de los objetivos clave del proyecto Nutri2Cycle, contribuyendo a cerrar la brecha de información ambiental que existe actualmente entre productores y consumidores. El primer paso para ello ha sido la aplicación de técnicas de metaanálisis a una amplia variedad de estudios publicados sobre los criterios que definen su compra. Los datos obtenidos en los más de 100 artículos examinados mostraron que la diferencia porcentual en la disposición de pago oscilaba entre el 2% y el 92%, situándose la media en un 33%, lo que significa que los consumidores estarían dispuestos a pagar alrededor de un 33% más por alimentos calificados como sostenibles. Esta variación dependía significativamente de la región del consumidor (la más alta se encontró en Asia, 65%), y de la categoría de alimentos (la más alta fue para los cereales y el pan, 60%). Los resultados mostraron también que la presencia de etiquetas ambientales no era un factor significativo en la

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

compra. La principal conclusión a extraer es por tanto que los consumidores sí saben qué es un alimento sostenible (ya que están dispuestos a pagar más por ellos) pero necesitan familiarizarse con los distintos tipos de ecoetiquetado, puesto que, en la actualidad, existen una gran variedad de ecoetiquetas con importantes diferencias en cuanto a alcance, significado etc. De hecho, los agricultores podrían beneficiarse del trabajo por conseguir una etiqueta, ya que los consumidores estarían dispuestos a pagar más. Sin embargo, actualmente el marco del etiquetado no está muy definido. Esto afecta directamente a su efectividad y por esta razón es necesario unificar los actuales esquemas de ecoetiquetado, con el objetivo último de permitir un proceso de toma de decisiones mucho más sencillo para consumidores y productores.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 21

Short title (in English):

PA21: Refining bio-based fertiliser has limited effect on potato yield

Short summary for practitioners (in English):

Processing manure can contribute to closing carbon (C) and nutrient loops, but this will only succeed when the products resulting from manure processing (also called bio-based fertiliser) are being accepted by arable farmers as a replacement for mineral fertilisers. This not only depends on the performance of these bio-based fertilisers compared to mineral fertiliser, but also on the costs and benefits. In this study, the effect of refining bio-based fertilisers was tested on potato yield. The less refined, and therefore cheaper, product (thin fraction of the digestate) as well as the refined product (ammoniumsulphate) showed a high nitrogen fertiliser replacement value (81% and 73% respectively). This means that both products are suited as a replacement for mineral N fertiliser. In the field, the different products showed limited differences in plant growth and yield which confirms the safe use of these products for potato growing. The fields that received only bio-based fertiliser showed similar results, but bio-based fertilisers will not be used as a replacement for animal manure in practice in the Netherlands due to the higher costs. Although this study concludes that both products are suitable as a replacement for mineral N fertiliser, only the refined product will potentially be used because it has the status of anorganic fertiliser.

Short title (native language):

Het verfijnen van mestproducten heeft gering effect op aardappeloogst

Short summary for practitioners (native language):

Het verwerken van mest kan bijdragen aan het sluiten van koolstof (C) -en nutriënten kringlopen, maar dat lukt alleen als de producten die door mestverwerking verkregen worden (ook wel bio-gebaseerde meststoffen genoemd) als kunstmestvervanger geaccepteerd worden door akkerbouwers. Dit hangt niet alleen af van de prestatie van deze bio-gebaseerde meststoffen ten opzichte van kunstmest, maar ook van de kosten -en baten. In deze studie werd het effect van verfijning van bio-gebaseerde mestproducten getest op aardappeloogst. Zowel het minder verfijnde, en dus goedkopere, product (dunne fractie van het digestaat) als het verfijnde product (ammoniumsulfaat) gaven een hoge stikstofkunstmest vervangingswaarde (81% en 73% respectievelijk). Dit betekent dat beide producten geschikt zijn om stikstofkunstmest te vervangen. In het veld toonden de geteste mestproducten weinig verschil in plantengroei en opbrengst. Dit bevestigt dat de bio-gebaseerde mestproducten veilig gebruikt kunnen worden voor de aardappelteelt. De velden die alleen bio-gebaseerde meststof ontvingen toonde vergelijkbare resultaten, maar vanwege de hogere kosten zullen deze meststoffen in de praktijk in Nederland niet snel gebruikt worden ter vervanging van dierlijke mest. Alhoewel deze studie concludeert dat beide producten stikstofkunstmest kunnen vervangen, zal in de praktijk

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

waarschijnlijk alleen het verfijnde product gebruikt worden omdat het de status van anorganisch meststof heeft

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 22

Short title (in English): Precision farming and optimised application: under-root application of liquid manure for maize and other row crops

Short summary for practitioners (in English)

In combination with precision farming, in under-root fertilization of maize seeds (or similar row crops), mineral fertilizers can be replaced by liquid organic fertilizers, such as liquid manure or biogas residue. This is the first precise application technology for liquid organic fertilizers for early under-root fertilization of maize, and potentially other row crops. In order to replace mineral fertilizer banded below seeds, a precise placement of manure close to the seeds (in the seeding lines and in a precise soil depth) is necessary. The new technology consists of a precise application technique of liquid organic fertilizer in terms of positioning, making use of GPS information, and in terms of dosage. Application of under-root fertilization can be carried out before or after sowing, even simultaneously. The preliminary conclusions are: (a) liquid manure for under-root fertilizer application instead of application of mineral P (and N) fertilizers has advantages with regard to the on-farm nutrient management; (b) in soils rich in P due to prior intensive manure application, under-root fertilization with liquid manure would reduce the P demand in form of mineral fertilizers; (c) in poor soils, this technique can increase particularly the P use efficiency; (d) N and P surplus thus can be reduced by reducing mineral fertilizer application around seeding; (e) results also show that under-root application of liquid manure can be combined with the strip-till technique; this combination makes it possible to make advantage of mulch sowing, which protects soils against erosion; (f) results showed that under-root application of liquid manure did not negatively affect yields and quality of silage maize.

Short title (native language):
Präzisionslandwirtschaft und optimierte Düngerausbringung: Unterfußdüngung von Mais (oder ähnlichen Reihenkulturen) mit organischen Flüssigdüngern

Short summary for practitioners (native language)

Mit der Unterfußdüngung von Mais (oder ähnlichen Reihenkulturen) kann in Kombination mit Maßnahmen der Präzisionslandwirtschaft Mineraldünger durch flüssige organische Dünger wie Gülle oder Biogasgärreste ersetzt werden. Es handelt sich um eine Neuentwicklung für die frühe Unterfußdüngung von Mais und ggf. andere Reihenkulturen mit organischen Flüssigdüngern. Um den i.d.R. unter Fuß ausgebrachten Mineraldünger adäquat ersetzen zu können, ist eine ebenso präzise Ausbringung der Gülle hinsichtlich der Positionierung (in den Saatlinien und in einer bestimmten Bodentiefe) unter Nutzung GPS-Informationen und hinsichtlich der Dosierung erforderlich, wobei die Applikation vor oder nach der Aussaat erfolgen kann. Die vorläufigen Schlussfolgerungen bezüglich der Unterfußdüngung bei Mais sind: (a) Die Verwendung von Gülle zur Unterfußdüngung anstelle von mineralischen P- (und N-) Düngern hat Vorteile im Hinblick auf das Nährstoffmanagement in den landwirtschaftlichen Betrieben; (b) in Böden mit hohem P-Gehalt aufgrund vorheriger intensiver

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Gülleausbringung würde die Unterfußdüngung mit Gülle den P-Bedarf in Form von Mineraldünger reduzieren; (c) in armen Böden kann diese Technik insbesondere die P-Nutzungseffizienz erhöhen; (d) N- und P-Überschüsse können durch die Reduzierung der Mineraldüngerausbringung vor oder kurz nach der Aussaat reduziert werden; (e) die Unterfußdüngung kann mit dem Strip Till-Verfahren kombiniert werden, wodurch auch gleichzeitig die Vorteile einer erosionsmindernen Mulchsaat nutzbar sind; (f) die Ergebnisse zeigen, dass die Unterfußdüngung mit Gülle keinen negativen Einfluss auf die Erträge und die Qualität von Silomais besitzen.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 23

Short title (in English):

PA23: Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations

Short summary for practitioners (in English)

The main aim of the deep-technology and product development driven BioPhosphate research (2002-2022) is to replace mineral fertilisers, most importantly the Cadmium and Uranium contaminated mineral and soft rock phosphate fertilizers, closing the CNP loops/reducing GHG emissions at less cost. High material core temperature, innovative zero emission pyrolysis (3R) applied to recover 35% P2O5 concentrated Phosphorus from pressure sterilized food grade cattle bone byproducts, which is than controlled release BIO-NPK-C compound biofertilizer formulated as of organic farmer user demands. The average dose is 300-500 kg/ha. The outcome of BioPhosphate research so far is TRL8, where the technology has been experimented in deployment conditions (i.e. real world) and proven its functioning in its final form with compliance with industrial/enviro standards of the addressed markets (EU, UK, USA, AU, JP). The BioPhosphate BIO-NPK-C compound biofertilizer products MS Authority permitted in 2020, fully meet the new 2022 EC Fertiliser criteria in several product functional categories and prepared for REACH certification (ongoing). As a result so far the BioPhosphate research so far already removed most technical/market risks, while majority of the underlying scientific/engineering problems being solved. The last research action is in progress, e.g. TRL9 first full industrial replication model deployed at 20,800 t/y capacity that is the ultimate evidence that research is successfully completed. TheBIO-NPK-C compound BioPhosphate biofertilizer is safer, better and less costly versus any market competitive product in the agri sector.

Short title (native language):

Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations

Short summary for practitioners (native language)

The main aim of the deep-technology and product development driven BioPhosphate research (2002-2022) is to replace mineral fertilisers, most importantly the Cadmium and Uranium contaminated mineral and soft rock phosphate fertilizers, closing the CNP loops/reducing GHG emissions at less cost. High material core temperature, innovative zero emission pyrolysis (3R) applied to recover 35% P2O5 concentrated Phosphorus from pressure sterilized food grade cattle bone byproducts, which is than controlled release BIO-NPK-C compound biofertilizer formulated as of organic farmer user demands. The average dose is 300-500 kg/ha. The outcome of BioPhosphate research so far is TRL8, where the technology has been experimented in deployment conditions (i.e. real world) and proven its functioning in its final form with compliance with industrial/enviro standards of the addressed markets (EU, UK, USA, AU, JP). The BioPhosphate BIO-NPK-C compound biofertilizer products MS Authority permitted in 2020, fully meet the new 2022 EC Fertiliser criteria in several product functional

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

categories and prepared for REACH certification (ongoing). As a result so far the BioPhosphate research so far already removed most technical/market risks, while majority of the underlying scientific/engineering problems being solved. The last research action is in progress, e.g. TRL9 first full industrial replication model deployed at 20,800 t/y capacity that is the ultimate evidence that research is successfully completed. TheBIO-NPK-C compound BioPhosphate biofertilizer is safer, better and less costly versus any market competitive productin the agri sector.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 24

Short title (in English):

PA24: Poultry manure derived biochar as a sorbent for removal of various contaminants

Short summary for practitioners (in English)

Extensive agriculture results in increasing amounts of phosphorous compounds in soils mostly due to the use of mineral fertilizers. In consequence, this biogen is transferred to water, and in turn can cause eutrophication of water reservoirs. Phosphorus fertilizers contain some heavy metals which can lead to soil contamination due to improper fertilization. What is more, excessive acidification of soils can contribute to mobility of heavy metals already present in soils. One of the potential solutions to mitigate and/or prevent from these threats is introducing to soils substances with suitable sorption properties such as biochars. The overall goal of this research was to evaluate the sorption properties of biochars produced from poultry manure. The obtained results demonstrated that sorption of phosphorus was above 95% of the applied dose. At the same time biochar produced from poultry manure at 425 °C showed not only high sorption capacity but also demonstrated desorption of phosphorus at around 21%. This biochar property could be of importance when it comes to agricultural soils where excessive phosphorus fertilization could be a threat. Such sorbent could also function as phosphorus storage. The research confirmed high efficiency (above 99%) of biochars to remove heavy metals ions, even at high concentrations in solutions (1000 mg L-1). Alkaline character of these biochars is also important. The application of obtained biochars to soils could prevent from excessive acidification of soils. In conclusion, the obtained poultry manure derived biochars can be valuable additives to soil, and thus prevent from improper fertilizing practices by immobilizing excessive amounts of phosphorus and at the same time limiting the mobility of selected contaminants such as heavy metals.

Short title (native language):

Wykorzystanie biowęgla z pomiotu kurzego do usuwania zanieczyszczeń obecnych w glebach

Short summary for practitioners (native language)

Intensywna produkcja rolna związana jest z wprowadzaniem do gleb dużych ilości związków fosforu obecnych w nawozach mineralnych. Migracja tego biogenu do wód, jest jedną z przyczyn eutrofizacji zbiorników wodnych. Obecne w nawozach fosforowych, pewne ilości metali ciężkich, przy niewłaściwym nawożeniu, mogą być źródłem zanieczyszczenia gleb. Ponadto nadmierne zakwaszanie gleb może powodować mobilność metali ciężkich obecnych w glebach. Jednym ze sposobów eliminacji tych zagrożeń jest wprowadzanie do gleb substancji o dobrych własnościach sorpcyjnych, np. biowęgla. Przedmiotem badań była ocena zdolności sorpcyjnych biowęgla wyprodukowanego z pomiotu kurzego. Badania wykazały, że zdolność do sorpcji fosforu jest na poziomie powyżej 95% zadanej dawki. Jednocześnie biowęgiel wytworzony w temperaturze 425 °C charakteryzował się nie tylko dużą pojemnością sorpcyjną, ale również zdolnością do desorpcji fosforu na poziomie 21%. Ta cecha biowęgla jest szczególnie przydatna w obszarach rolniczych, gdzie nadmierne stosowanie nawozów fosforowych jest zagrożeniem, a jednocześnie sorbent może być rezerwuarem tego biogenu. Przeprowadzone badania potwierdziły również wysoką skuteczność (powyżej 99% zawartości początkowej) biowęgli w

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

usuwaniu jonów metali ciężkich, nawet przy ich dużej koncentracji w roztworze (1000 mg L-1). Istotny jest również alkaliczny charakter tych sorbentów. Stosowanie biowęgli w uprawach może przeciwdziałać nadmiernemu zakwaszeniu gleb. Zatem wytworzone sorbenty są dobrym dodatkiem glebowym, mogącym przeciwdziałać złym praktykom nawozowym poprzez unieruchomienie nadmiernej ilości fosforu przy jednoczesnym ograniczeniu mobilności innych zanieczyszczeń, np. metali ciężkich.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 25

Short title (in English):

PA25: Fertilizing products from poultry manure

Short summary for practitioners (in English)

Due to chemical composition and properties poultry manure is considered a valuable substrate to obtain fertilizing products such as composts and biochars. Compost from poultry manure compared to poultry manure when applied to fields does not contribute to excessive gaseous emissions including ammonia or carbon dioxide. It is microbiologically safe, and thus does not pose any threat to the environment. Biochars produced through pyrolysis of poultry manure can be used in composting as a supplementary material in composting mixtures to limit nitrogen loss during composting. Poultry derived biochar can be also used as an additive to mature composts or as a soil enhancer directly introduced to soils. The main goal of this research is to convert poultry manure into composts such as nitrogen losses can be limited during the process and to evaluate the obtained composts, composts mixed with poultry manure derived biochar and poultry manure derived biochar itself for fertilization of soils with low organic matter. So far, the results show that the obtained compost from poultry manure fulfils the requirements for fertilizers. It is microbiologically safe (free from pathogens), contains 73% of organic matter, 41.7% of carbon, 1.8% of nitrogen, 8.1% of phosphorous, C/N of 22 and pH of 9.2. Currently, the pot experiments with selected growing media amended with poultry manure composts, biochars and their mixtures are in progress. They are aimed to evaluate the effect of poultry manure derived fertilizing products on soil properties and growth of selected plants.

Short title (native language):

Produkty nawozowe z pomiotu kurzego

Short summary for practitioners (native language)

Z uwagi na skład i właściwości pomiot kurzy stanowi wartościowy substrat do otrzymywania różnych produktów nawozowych takich jak komposty czy biowęgle. Kompost z pomiotu kurzego w porównaniu do świeżego pomiotu kurzego nie wydziela do atmosfery dużych ilości gazów tj. amoniak czy dwutlenek węgla. Jest również stabilny mikrobiologicznie, dzięki czemu nie stanowi zagrożenia dla środowiska. Biowęgiel otrzymane w wyniku pirolizy pomiotu kurzego mogą być wykorzystane w procesie kompostowania jako dodatek do mieszanek kompostowych, który będzie ograniczał straty azotu podczas samego procesu. Może być również wykorzystany jako dodatek do dojrzałych kompostów lub jako polepszacz glebowy wprowadzany bezpośrednio do gleb. Głównym celem badań jest uzyskanie kompostów z pomiotu kurzego przy jednoczesnym ograniczeniu strat azotu podczas samego procesu kompostowania oraz ocena kompostów z pomiotu kurzego oraz ich mieszanek z biowęglem otrzymanym z pomiotu kurzego do nawożenia gleb ubogich w materię organiczną. W wyniku przeprowadzonych badań otrzymano kompost z pomiotu kurzego, który spełniał wymagania dla nawozów. Był bezpieczny pod względem sanitarnym (wolny od jaj pasożytów i bezpieczny mikrobiologicznie), zawierał 73% materii organicznej, 41.7% węgla, 1.8% azotu, 8.1% fosforu, stosunek węgla do azotu to 22, a pH 9.2. Obecnie prowadzone są doświadczenia wazonowe z wybranymi

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

podłożami wzrostowymi, które pozwolą na określenie wpływu dodatku kompostów z pomiotu kurzego, ich mieszanek z biowęglem i biowęgla z pomiotu kurzego na właściwości gleb i wzrost wybranych roślin.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 26

Short title (in English):

PA26: Energy recovery from poultry manure

Short summary for practitioners (in English)

Poultry manure, due to the high content of organic substances, are an attractive raw material for biogas production, however, mono-digestion in their case may be difficult due to the low C/N ratio. Therefore, it seems reasonable to optimize the substrate, obtained by creating a homogeneous mixture of manure with other organic waste and their co-digestion. For this reason, in our study we tested the possibility of anaerobic co-digestion of poultry manure with sewage sludge. The proposed solution, seems to be very interesting option, because it leads to an enhanced production of biogas (>40%), as well as volatile solids removal (>20%). In this context, the implementation of this solution in WWTPs provides an unique opportunity for these facilities to improve their energy self-sufficiency as well as profitability which are possible by enhancing energy recovery from sludge as well as full utilisation of the existing infrastructure (oversized digesters) and hence creates a new place for the treatment of the poultry manure. Moreover, considering the solution at the investment planning stage may significantly impact the disposal capacity per volume unit of the digester, thereby affecting investment costs. However, the implementation of this solution in the wastewater treatment plant is still a big challenge and needs further studies including the identification of optimal digesting conditions, information about substrate pumping, infrastructure for WWTP (e.g. efficiency co-generation devices, energy consumption in activated sludge system, inhibition thresholds and processing properties). Other challenging task for future research is: 1) the identification of the microbial community structure which can vary in response to the changing environmental conditions such as: OLR, HRT; 2) optimization of feedstock composition.

Short title (native language):

Odzysk energii z pomiotu kurzego

Short summary for practitioners (native language)

Pomiot kurzy, ze względu na wysoką zawartość substancji organicznych, jest atrakcyjnym surowcem do produkcji biogazu, jednak jego monofermentacja może być utrudniona ze względu na niski iloraz C/N. Dlatego też, zasadna wydaje się optymalizacja wsadu poprzez stworzenie jednorodnej mieszaniny obornika z innymi odpadami organicznymi i ich wspólne przetwarzanie (kofermentacja). Z tego powodu, w naszych badaniach sprawdziliśmy możliwość beztlenowej kofermentacji obornika drobiowego z osadami ściekowymi. Zaproponowane rozwiązanie wydaje się być bardzo interesującą opcją, ponieważ prowadzi do zwiększenia produkcji biogazu (>40%), jak również stopnia przefermentowania (>20%). W tym kontekście, wdrożenie tego rozwiązania w oczyszczalniach ścieków stwarza unikalną szansę dla tych obiektów na poprawę samowystarczalności energetycznej oraz

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

rentowności, które są możliwe dzięki zwiększeniu odzysku energii z osadów, jak również pełnemu wykorzystaniu istniejącej infrastruktury (przewymiarowane komory fermentacyjne), a tym samym stwarza nowe miejsce dla przetwarzania pomiotu kurzego. Ponadto, uwzględnienie tego rozwiązania na etapie planowania inwestycji może znacząco wpłynąć na wydajność utylizacji w przeliczeniu na jednostkę objętości komory fermentacyjnej, a tym samym na koszty inwestycji. Jednakże wdrożenie tego rozwiązania w oczyszczalni ścieków jest nadal dużym wyzwaniem i wymaga dalszych badań obejmujących określenie optymalnych warunków fermentacji, informacji na temat pompowania substratów, infrastruktury dla oczyszczalni ścieków (np. sprawności urządzeń kogeneracyjnych, zużycia energii w komorach osadu czynnego, progów inhibicji oraz parametrów procesu). Innymi wyzwaniami dla prowadzonych badań są: 1) identyfikacja struktury zbiorowiska mikroorganizmów, która może zmieniać się w odpowiedzi na zmieniające się warunki środowiskowe, takie jak: OLR, HRT;
2) optymalizacja składu substratów.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 27

Short title (in English):

PA27: Using soil electrical conductivity and NDVI to idenitify distinct fertilizing areas in a vineyard

Short summary for practitioners (in English)

The intensification of agriculture has greatly enhanced crop productivity, much needed with the present population growth, but its potential environmental impact also increased. Precision agriculture has potential to tackle this challenge and the present work is framed within that context, as it intends to study the spatial variability of soils in order to precisely apply organic fertilizers. For this, three distinct zones were defined in a 6.77 ha vineyard based on high and low values of 1) apparent soil electrical conductivity (ECap), measured using an indirect sensor (Geonics EM38®), and 2) normalized difference vegetation index (NDVI), obtained from satellite images. Soil samples from each zones were then collected and chemically analysed. Most of the selected soil chemical properties, such as nutrients concentration, varied significantly among zones, showing a potential for differential application of fertilizers. Regarding soil mineralogy, significant differences were also observed between zones, as zones defined with high ECap showed higher percentage of clay and lower percentage of sand, with the opposite also true. Another reassuring but expectable outcome was the fact that zones with high NDVI presented the highest concentration of soil nitrogen and phosphorus. Both indicators are non-destructive, cost less and require less labour and, as seen, has showed efficiency in the delineation of distinct zones and in providing information about soil properties. With this information, the farmer knows which areas lack or have an excess of a specific nutrient and manage soil and crop fertilization in accordance, thus applying only the necessary amount or providing higher amounts in the poorer areas, resulting in a more evenly production.

Short title (native language):

Uso da condutividade elétrica aparente do solo e de NDVI para o delineamento de zonas de gestão numa vinha

Short summary for practitioners (native language)

A intensificação da agricultura aumentou consideravelmente a produtividade das culturas, contudo, o impacto associado também aumentou. A Agricultura de Precisão tem potencial para enfrentar este desafio e o presente trabalho insere-se neste contexto, visto que pretende estudar a variabilidade espacial do solo de forma a aplicar com precisão os fatores de produção, nomeadamente fertilizantes. Assim, numa vinha de 6,77 ha foram definidas três zonas distintas, com base em valores altos e baixos de 1) condutividade elétrica aparente do solo (ECap), medida através de um sensor (Geonics EM38®), e 2) índice de vegetação por diferença normalizada (NDVI), obtido a partir de imagens de satélite. Amostras de solo dessas zonas foram então colhidas e analisadas. A maioria das propriedades químicas do solo estudadas, como a concentração de nutrientes, variou significativamente entre zonas, evidenciando potencial para a aplicação diferenciada de fertilizantes. Em relação à mineralogia do solo,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

foram também observadas diferenças significativas entre zonas, onde zonas definidas com alto ECap apresentaram maior percentagem de argila no solo e menor percentagem de areia, e o contrário também se observou. Outro resultado otimista, mas expectável, foi o fato de as zonas com alto NDVI apresentarem as maiores concentrações de azoto e fósforo no solo. Ambos os indicadores são não-destrutivos, mais económicos e requerem menos mão de obra e foram eficazes no delineamento de zonas distintas e no fornecimento de informações sobre as propriedades do solo. Dessa forma, o agricultor consegue aplicar fertilizantes de acordo com a carência ou excesso de nutrientes de um dado local, aplicando apenas o necessário ou reforçando as áreas mais pobres, o que resulta numa produção mais homogénea.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 28

Short title (in English)

PA28: Farm scale anaerobic digestion of agro-residues to increase local nutrient cycling & improve nutrient use efficiency

Short summary for practitioners (in English)

Farm scale anaerobic digestion (AD) is a technology by which farmers can create renewable energy by valorising agricultural residues. The AD process takes place in a large reactor in the absence of oxygen, where organic material (e.g. manure or crop residues) is being converted into biogas. The biogas (mainly methane) is subsequently burned in a combined heat and power (CHP) unit and results in a renewable energy source in the form of heat and electricity. The fermented biomass is called digestate and can be used on the farm as organic fertilizer.

The majority of the 50+ farm scale anaerobic digesters in Flanders are active on dairy farms and run on mono digestion of cattle slurry. Other agricultural sectors (pig farming or vegetable farming) however also show potential for the application of farm scale AD. The most important conditions to be an economically feasible case on farms appear to be a sufficiently high demand for electricity on the farm, the availability of sufficient agricultural residual flows and limited additional cost (e.g. for potential extra pretreatment steps or logistic aspects).

Pig farming in particular seems to be highly interesting to apply farm scale AD. To validate the feasibility of performing mono digestion of pig manure in a stable way, Inagro performed a pilot scale test in their farm scale digester (31 kW) during three months. The input feed consisted of the solid fraction coming from an adapted stable system and pig slurry (to decrease the dry matter content in order to prevent operational problems).

Short title (native language):

Pocketvergisting van agrarische reststromen om de efficiëntie van het nutriëntengebruik te verbeteren

Short summary for practitioners (native language):

Pocketvergisting is een technologie waarmee landbouwers hernieuwbare energie kunnen produceren door de valorisatie van reststromen. Het proces vindt plaats in een grote reactor in afwezigheid van zuurstof, waar organisch materiaal (bv. mest of gewasresten) wordt omgezet in biogas. Het biogas (voornamelijk methaan) wordt vervolgens verbrand in een warmtekrachtkoppelingsinstallatie (WKK) en levert hernieuwbare energie in de vorm van warmte en elektriciteit. De vergiste biomassa wordt digestaat genoemd en kan op de landbouwbedrijf worden gebruikt als organische meststof.

De meeste van de meer dan 50 pocketvergisters in Vlaanderen zijn actief op melkveebedrijven en werken op monovergisting van runderdrijfmest. Andere landbouwsectoren (varkenshouderij of groenteteelt) tonen echter ook potentieel voor de toepassing van deze technologie. De belangrijkste voorwaarden voor een economisch haalbare toepassing op landbouwbedrijven lijken een voldoende grote vraag naar elektriciteit op het bedrijf, de beschikbaarheid van voldoende agrarische reststromen en beperkte meerkosten (bv. voor mogelijke extra voorbehandelingsstappen of logistieke aspecten) te zijn.

Met name de varkenshouderij is zeer interessant voor toepassing van pocketvergisting. Om de haalbaarheid van monovergisting van varkensmest op een stabiele manier te valideren, voerde Inagro

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

gedurende drie maanden een piloottest uit in hun pocketvergister (31 kW). De toevoer bestond uit de vaste fractie afkomstig van een aangepast stalsysteem en varkensdrijfmest (om het drogestofgehalte te verlagen om operationele problemen te voorkomen).

Results (in English)

Results showed that farm scale AD of pig manure seems feasible. However, it is important to keep in mind some specific points of attention: primary separated manure has a higher biogas potential than pig slurry and fresh manure is crucial to obtain as much energy as possible. By an adapted stable system, farm scale AD has the potential to be expanded to pig farms, although it should be noted that the profitability of this technology is strongly farm-specific.

Although the research revealed that vegetable residues can be properly digested, the main bottleneck is the number of farms that can provide sufficient vegetable residues year round and some logistic aspects.

Results (native language)

De resultaten toonden aan dat pocketvergisting van varkensmest haalbaar lijkt. Het is echter belangrijk om aandacht te hebben voor enkele specifieke aandachtspunten: primair gescheiden mest heeft een hoger biogaspotentieel dan varkensdrijfmest en verse mest is cruciaal om zoveel mogelijk energie te verkrijgen. Door een aangepast stalsysteem heeft pocketvergisting het potentieel om uitgebreid te worden naar varkensbedrijven, hoewel opgemerkt moet worden dat de rendabiliteit van deze technologie sterk bedrijfsspecifiek is.

Hoewel uit het onderzoek bleek dat groenteresten een goed biogaspotentieel hebben, is het belangrijkste knelpunt het aantal bedrijven dat het hele jaar door voldoende groenteresten kan leveren in combinatie met een aantal logistieke aspecten.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 29

Short title (in English):

PA29: Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment

Short summary for Practitioners (in English):

Large surpluses of on-farm N and P are processed or exported out of Flanders while tons of synthetic N-fertilisers are purchased and used for crop production. The use of recycling-derived fertilisers (RDFs) from manure can counter this situation. Currently, RDFs derived from animal manure still need to comply with the legal application constraints of animal manure and are thus not often used.

That is why five RDFs (ammonium nitrate and ammonium sulphate (from stripping-scrubbing), digestate from co-digestion of pig manure, liquid fraction of digestate and pig urine) were compared with mineral fertiliser CAN, pig manure and a blank treatment in a 3-year field trial focusing on short term N-effects of the RDFs. During the first (crop: maize) and second (crop: spinach) year, the weather conditions were extremely dry and hot. Therefore water availability became the principal factor determining crop growth. In these extreme conditions, no significant differences in fresh and dry yield were observed for the different objects. Residual nitrate of all RDFs was comparable to mineral fertilizers.

During the third year (crop: early potatoes), the weather conditions were wet and rather cold. Intensive precipitation led to nitrate leaching so crop yield was lower than expected in all objects. In these circumstances, delayed N mineralization from pig slurry may have coincided better with the N uptake from the early potatoes, leading to a somewhat better (not significant) yield. N - mineralization from digestate however appeared to happen too late for the potatoes (N demand is high in the early phases of the growing season in early potatoes). This may also explain the (not significant) higher residual nitrate in the soil after digestate at harvest.

Short title (native language)

Korte stikstof termijneffect van herwonnen meststoffen met focus op gewasopbrengst en stikstofverliezen naar het milieu.

Short summary (native language)

Het mestoverschot in Vlaanderen wordt verwerkt en geëxporteerd, terwijl kunstmest wordt aangekocht om in de gewasbehoefte te voorzien. Nochtans kan gebruik van herwonnen meststoffen dit oplossen. Echter moeten deze voldoen aan de wettelijke toepassingsvereisten van dierlijke mest waardoor het gebruik laag is. Daarom werden de korte termijneffecten van 5 herwonnen meststoffen (ammoniumnitraat, sulfaat, digestaat, dunne fractie digestaat, varkensurine) vergeleken met KAS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

kunstmest, varkensmest en een blanco behandeling in een driejarige veldproef. Het doel van de proef was om een verband te leggen tussen de hoeveelheid N die wordt aangebracht en de drogestofproductie. Weersomstandigheden tijdens groeiseizoen speelden een sterke rol met extreem droog en warm weer in jaar 1, 2 en nat en koud in jaar 3. In Jaar 1 (maïs),2 (spinazie) was nitraatresidu voor alle herwonnen meststoffen gelijkaardig aan kunstmest. Jaar 3 leidde intensieve neerslag tot nitraatuitspoeling zodat de gewasopbrengst in alle objecten lager was dan verwacht. In deze omstandigheden viel de vertraagde N-mineralisatie uit varkensdrijfmest wellicht beter samen met de N-opname door vroege aardappelen, met iets betere (niet significante) opbrengst. N-mineralisatie uit digestaat bleek echter te laat te gebeuren voor de aardappelen: N vraag is hoog in de vroege fasen van het groeiseizoen bij vroege aardappelen. Dit kan ook het (niet significante) hogere restnitraat in de bodem na digestaat bij de oogst verklaren.

Results (in English)

In general, it can be concluded that the both the agronomic (fresh and dry yield) and environmental (post-harvest residual nitrate) value of several tested RDFs (ammonium nitrate, ammonium sulphate, digestate, liquid fraction of digestate, pig urine) perform similarly as their mineral counterparts and pig manure, for several tested crops (maize, spinach, early potatoes). During this field trial, weather conditions were the principal factor determining crop growth.

However, attention should be paid to the application of ammonium nitrate for drought sensitive crops (such as spinach) since a lower yield was observed during the second year, probably due to soil treatment.

Results (native language)

In het algemeen kan besloten worden dat zowel de landbouwkundige (opbrengst verse en droge stof) als de milieukundige (restnitraat na oogst) waarde van verschillende geteste herwonnen meststoffen (ammoniumnitraat, ammoniumsulfaat, digestaat, dunne fractie van digestaat, varkensurine) vergelijkbaar zijn met minerale meststoffen en varkensmest, voor verschillende geteste gewassen (maïs, spinazie, vroege aardappelen). Tijdens deze proef waren de weersomstandigheden de belangrijkste factor die de gewasgroei bepaalt.

Er moet echter aandacht worden besteed aan de toepassing van ammoniumnitraat voor droogtegevoelige gewassen (zoals spinazie), aangezien er een lagere opbrengst werd waargenomen tijdens het tweede jaar, waarschijnlijk als gevolg van de bodembehandeling.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 30

Short title (in English)

PA30: Why we should dive into potassium when growing duckweed

Short summary for Practitioners (in English)

Pig farmers struggle to dispose all manure on farm. (Processed) manure involves laborious and expensive transport. The fast growing plant duckweed might be a solution because it requires a lot of nitrogen (N) and phosphorus (P) to sustain its growth.

The principle is simple: (de-)nitrified effluent is added to a pond of water, and the plant takes up all N and P it requires. By doing so, the effluent can be discharged without a negative impact on the natural ecosystem and at the same time, a protein rich plant is produced which is a source of essential minerals, which could be used in animal feed.

Maximizing the addition of the (de-)nitrified effluent from pig manure within the legal limits, can still cause troubles. N is taken up, but the effluent contains more potassium (K) than required for the plant growth. As a result, K slowly builds up, until it becomes toxic for duckweed. In the project we determined a method to estimate the speed of the accumulation. We found that the depth of the pond dilutes the nutrient build up and acts as a buffer. A pond depth of 1 m allows the K levels to be below any toxicity levels after one growing season. Each winter, the pond can be discharged and refreshed with rain water. Sadly, the K cycle is generally overlooked in legislation and research. We learned to increase the amount of the unprocessed liquid fraction of pig manure in our pond.

Short title (native language)

Dieper duiken in de kaliumkringloop bij het kweken van eendenkroos

Short summary (native language)

Varkenshouders hebben moeite om alle mest op hun boerderij af te voeren. (Bewerkte) mest brengt arbeidsintensief en duur transport met zich mee. Het snelgroeiende eendenkroos zou een oplossing kunnen zijn, omdat het veel stikstof (N) en fosfor (P) nodig heeft om te blijven groeien.

Het principe is eenvoudig: (gede)nitrificeerd effluent wordt aan een waterplas toegevoegd en de plant neemt alle N en P op die hij nodig heeft. Hierdoor kan het effluent worden geloosd zonder negatieve gevolgen voor het natuurlijke ecosysteem en wordt tegelijkertijd een eiwitrijke plant geproduceerd die een bron is van essentiële mineralen die kunnen worden gebruikt in veevoer.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Het maximaliseren van de toevoeging van het (gede)nitrificeerde effluent uit varkensmest binnen de wettelijke grenzen, kan alsnog voor problemen zorgen. Er wordt N opgenomen, maar het effluent bevat meer kalium (K) dan nodig is voor de plantengroei. Hierdoor bouwt K zich langzaam op, totdat het giftig wordt voor kroos. In het project hebben we een methode bepaald om de snelheid van de accumulatie te schatten. We ontdekten dat de diepte van de vijver de opbouw van voedingsstoffen verdunt en als buffer fungeert. Een vijverdiepte van 1 m zorgt ervoor dat de K-niveaus na één groeiseizoen onder het eventuele toxiciteitsniveau liggen. Elke winter kan de vijver worden geloosd en ververst met regenwater. Helaas wordt de K-cyclus over het algemeen over het hoofd gezien in wetgeving en onderzoek. We hebben geleerd om de hoeveelheid onbewerkte vloeibare fractie van varkensmest in onze vijver te vergroten.

Results (in English)

Duckweed can produce 3.5 t proteins ha^{-1} yr^{-1} in outdoor conditions in Flanders on the effluent of pig manure treatment, which outperform soybean productivity. Furthermore, potential harmful heavy metals are below feed limits and duckweed can also be seen as a source of Mn, Zn and Fe.

In the cultivation of duckweed, rates of potassium recycling greatly impact the overall environmental impacts. It is advised to have a buffer for nutrient accumulation of at least 1 m (pond depth) in the case of nitrified and de-nitrified pig manure effluent.

Results (native language)

Eendenkroos kan 3,5 ton eiwit ha-1 jr-1 produceren onder buitenomstandigheden in Vlaanderen op het effluent van varkensmestverwerking, wat beter is dan de productiviteit van sojabonen. Bovendien liggen de potentieel schadelijke zware metalen onder de voederlimieten en kan eendenkroos ook beschouwd worden als een bron van Mn, Zn en Fe. Bij de kweek van eendenkroos heeft de kaliumkringloop een grote invloed op de algemene milieueffecten. Er wordt geadviseerd om een buffer voor nutriëntenaccumulatie van minstens 1 m (vijverdiepte) te hebben bij het gebruik van varkensmesteffluent.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 31

Short title (in English)

PA31: Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil

Short summary for Practitioners (in English)

The solution encompasses a plant performing anaerobic digestion of sewage sludge and a “stripping system” extracting ammonia to increase the plant's digestion efficiency and produce ammonium sulphate, which can be used as valuable fertilizer or sold for industrial uses. Digestate and ammonium sulphate are used to fertilise crop, zeroing the use of synthetic fertilisers and providing valuable organic matter to the soil. Minimum tillage and precision distribution of digestate is implemented.
To investigate the effect of the combined use of digestate, precision agriculture and no-tillage, field trials were set up close to the abovementioned facility. Two crops, rice and wheat, were considered and a randomised field test was performed. The investigated theses were: i)fertilisation with digestate+ AS distribution ii) fertilization with urea iii) no fertilisation(control) During the agricultural season, ammonia emissions nitrous oxide, methane, and carbon dioxide emissions were measured Odour emissions during fertilization are evaluated, and changes in main soil characteristics are also analysed. All agronomical data related to fertilization, field management, and irrigation operations were collected, together with yield data.

Short title (native language)

Utilizzo di digestato, agricoltura di precisione e minima lavorazione per aumentare la qualità del suolo e lo stoccaggio di sostanza organica

Short summary (native language)

La soluzione include un impianto di digestione anaerobica alimentato a fanghi di depurazione e un “sistema di strippaggio” per estrarre ammoniaca, aumentare l'efficienza di digestione dell'impianto e produrre solfato di ammonio, utilizzato come fertilizzante o venduto per usi industriali. Il digestato e il solfato di ammonio vengono utilizzati per la concimazione delle colture, azzerando l'uso di fertilizzanti di sintesi e apportando sostanza organica al suolo. Allo stesso tempo viene implementata la lavorazione minima e la distribuzione precisa del digestato. Per indagare l'effetto dell'uso combinato di digestato, agricoltura di precisione e minima lavorazione del terreno, sono state allestite prove in campo nei pressi dell'impianto. Sono state prese in considerazione due colture, riso e grano. Le tesi indagate sono state: i) fertilizzazione con distribuzione digestato+AS ii) fertilizzazione con urea iii) assenza di fertilizzazione(controllo). Durante la stagione agricola sono state misurate le emissioni di ammoniaca, le emissioni di protossido di azoto, metano e anidride carbonica.Durante la concimazione sono state misurate le emissioni di odore e le variazioni delle principali caratteristiche del suolo. Sono stati raccolti i dati agronomici relativi alle operazioni di fertilizzazione, gestione del campo e irrigazione, insieme ai dati di resa.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

Results (in English)

Data collected have demonstrated that odour and ammonia emissions during soil application of digestate are similar to those from mineral fertilizer when digestate injection in the soil is used as an application technique instead of traditional spreading on the soil surface. Similar outcomes for GHGs emissions such as CO_2 and CH_4 showed no differences among digestate and control fertilisation.

in details main results of experimentation can be unpacked as such:

I. Analyses on rice grain showed similar composition for chemical fertilizers and for digestate + ammonium sulphate fertilization.
II. Using digestate + ammonium sulphate determined the increase of soil organic matter by 16% respect to the initial content (7.5 tons of carbon per hectare)
III. Nitrate leaching in digestate + ammonium sulphate fertilization resulted very low, analogous to the leaching detected in the chemical treatment and the untreated plot
IV. the solution proved to cause the same direct emissions on fields (N_2O and CH_4) as the use of chemical fertilizers (urea).
V. the solution proved to cause the same ammonia emissions on fields as the use of chemical fertilizers (urea).

Results (native language)

I dati raccolti hanno dimostrato che le emissioni di odore e ammoniaca durante l'applicazione del digestato al suolo sono simili a quelle del fertilizzante minerale quando si usa un sistema di iniezione Allo stesso modo la misura delle emissioni di gas serra come CO2 e CH4 non ha mostrato differenze tra il digestato e la fertilizzazione tradizionale (urea) e il controllo (nessuna fertilizzazione).

In dettaglio i principali risultati della sperimentazione:

I. Le analisi sulla granella di riso hanno mostrato una composizione simile per il raccolto ottenuto dalle parcelle con fertilizzanti chimici e per la concimazione digestato + solfato di ammonio.
II. L'utilizzo di digestato + solfato di ammonio ha determinato l'aumento di sostanza organica del suolo pari al 16% rispetto al contenuto iniziale (circa 7.5 tonnellate di carbonio per ettaro)
III. La lisciviazione di nitrati nella concimazione digestato + solfato ammonico è risultata molto bassa, analoga alla lisciviazione rilevata nel trattamento col fertilizzante chimico e nell'appezzamento non trattato
IV. la soluzione ha determinato le stesse emissioni dirette sui campi (N2O e CH4) dell'utilizzo di fertilizzanti chimici (urea).
V. la soluzione ha determinato le stesse emissioni di ammoniaca dell'uso di fertilizzanti chimici (urea).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 32

Short title (in English)

PA32: Producing bio-fertilisers from pig manure through different separations stages

Short summary for Practitioners (in English)

Intensive livestock activity in Lombardy (northern Italy) and in other regions in Europe (like Denmark; Catalonia, Spain; Flanders, Belgium; Netherlands) is causing several environmental issues. The nitrates directive limits the amount of manure that can be used in fields (depending on if the area is considered vulnerable or not). The possibility to export some fractions of the effluent can increase the number of livestock heads without jeopardising the environment.

The solution has the aim to reduce pig slurry volumes to allow a better management of nutrients, both for export from livestock areas and on site (top dressing with ready effect nitrogen). The products are: a solid fraction (19% ww), a concentrate (a RENURE like material, 33% ww) and clean water (48% of mass). The plant separates the effluent in a solid fraction (19%), which will be composted and a liquid fraction. The latter is further separate thanks to reverse osmosis (super tight filtrations) in clean water (48%) and a concentrate (33%) that can be exported from the farm as RENURE (it could be considered a chemical fertiliser instead of livestock effluent). The liquid concentrate has high concentration of ready-to-use nutrients for plants. Field experiment on corn demonstrate to demonstrate that fertilisation with concentrate is as good as a chemical fertilisation (urea), as yield were the same.

Due to NVZ limit (170 kg ha of animal nitrogen), slurry must often be exported and chemical fertilisers must be supplied to meet the crop needs. If mineral concentrate such the one produced will be considered as mineral fertilizer, it means that the solid fraction resulting from slurry treatment can be used for sowing within Nitrate Directive limits (170 kg ha^{-1}) while the mineral concentrate (RENURE) could be used instead of mineral fertilisers in top dressing (exceeding the NVZ limits), therefore avoiding the need of chemical fertilizers. The possibility to use mineral concentrate exceeding the Nitrate Directive limits, could make the farm self-sufficient in terms of N-fertilizer supply and could eliminate the need to export material outside the farm area.

Short title (native language)

Produzione di bio-fertilizzanti da liquame suino attraverso stadi di separazione

Short summary (native language)

L'allevamento intensivo in Lombardia e in altre regioni d'Europa causa diversi problemi ambientali. La Nirettiva Nitrati limita la quantità di refluo utulizzabile nei campi. La possibilità di esportare alcune frazioni degli effluenti può aumentare il numero di capi di bestiame senza compromettere l'ambiente. La

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

soluzione ha l'obiettivo di ridurre i volumi del liquame suino per consentire una migliore gestione dei nutrienti, in loco e per agevolare l'export

I prodotti sono: una frazione solida (19% ww), un concentrato (un materiale tipo RENURE, 33% ww) e acqua pulita (48% della massa). L'impianto separa l'effluente in una frazione solida (19%), che verrà compostata, e una frazione liquida. Quest'ultimo è ulteriormente separato grazie all'osmosi inversa in acqua pulita (48%) e un concentrato (33%) che può essere esportato dall'azienda agricola come RENURE. Il concentrato liquido ha un'alta concentrazione di nutrienti pronti ad essere assimilati dalle piante. Esperimenti in campo su mais hanno dimostrato che la concimazione con concentrato è valida quanto una concimazione chimica (urea), determinando le medesime rese.

Results (in English)

The solution has the aim to reduce pig slurry volumes to allow a better management of nutrients, both for export from livestock areas and on site (top dressing with ready effect nitrogen). The products are: a solid fraction (19% ww), a concentrate (a RENURE like material, 33% ww) and clean water (48% of mass). The plant separates the effluent in a solid fraction (19%), which will be composted and a liquid fraction. The latter is further separate thanks to reverse osmosis (super tight filtrations) in clean water (48%) and a concentrate (33%) that can be exported from the farm as RENURE (it could be considered a chemical fertiliser instead of livestock effluent). The liquid concentrate has high concentration of ready-to-use nutrients for plants. Field experiment on corn demonstrate to demonstrate that fertilisation with concentrate is as good as a chemical fertilisation (urea), as yield were the same.

Results (native language)

La soluzione ha l'obiettivo di ridurre i volumi del liquame suino per consentire una migliore gestione dei nutrienti, sia per l'esportazione dalle zone di allevamento che in loco (top dressing con azoto pronto effetto). I prodotti sono: una frazione solida (19% ww), un concentrato (un materiale tipo RENURE, 33% ww) e acqua pulita (48% della massa).. Il concentrato liquido (che potrebbe essere considerato un fertilizzante chimico piuttosto che azoto di origine animale) ha un'alta concentrazione di nutrienti pronti all'uso per le piante. Esperimenti in campo su mais dimostrano che la concimazione con concentrato è valida quanto una concimazione chimica (urea), a parità di resa.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 33

Short title (in English)

PA33: Environmental and social life cycle assessments of nutrient recovery technologies in agriculture

Short summary for Practitioners (in English)

This study assessed a selected range of innovative agricultural technologies (12 in total) aimed at closing loops of Nitrogen (N), Phosphorus (P) and Carbon (C) with regards to their overall environmental and social performance.

All environmental life cycle assessments (eLCAs) were compliant with the EU Product Environmental Footprint methodology. Data inventories were based on data from technology providers, field scale modelling, literature and/or the ecoinvent database. Given the different purposes of the technologies (e.g. slurry ammonia volatilisation reduction vs. waste stream P recovery), they cannot sensibly be compared on how much they improve C, N and P recovery and recycling. Therefore, each technology was compared against a baseline without the technology, to quantify the environmental benefits and drawbacks in relative terms.

Further, Dashboard Indicators (DBI) of environmental impacts, assessed qualitatively by experts, were compared against the quantitative LCA results, to see if these simple DBI could provide useful technology guidance, saving more comprehensive LCA studies. This comparison of DBI vs. LCA can provide useful learnings for where and how to improve guidelines for DBI assessment.

Finally, the social LCA study selected and tested a range of indicators of potential social hotspots and opportunities related to the implementation of these novel technologies.

Results (in English)

The majority of the technologies assessed reduce greenhouse gases and nitrogen losses, leading to reduced impacts of acidification and climate change potential[1]. To achieve reductions, these technologies consume energy and materials, which sometimes increased impacts as human toxicity and non-renewable resource use. There was an equal proportion of technologies which increase or decrease impacts on eutrophication.

The agreement between DBI and LCA results was less than 50%. Good agreement was found for carbon footprint and nutrient recovery. However, in many cases, expert assessed DBIs gave too optimistic scores about a technology's performance (e.g., N_2O emissions or rock P consumption). In contrast, DBIs were over-pessimistic with regards to soil quality. Improved guidance for expert assessment of the more difficult DBI is therefore necessary to make the DBI approach valid.

For the social impacts, the majority of technologies increases demand for highly skilled workers and improves efficiencies. Some of the technologies reduced odours, minimised work accidents and may

[1] E.g. for Impact category 'Climate change' LL1+2 (ammon.stripping), 6 (conc. Vacuum strip), LL11 (manure solids bedding), LL18 (slurry acid), LL41 (float wetland plants), LL49 (manure struvite recov.), LL55 (manure solids proc.), LL65 (wastewater struvite) and for Impact category 'Acidification' LL11, LL17 (dairy sludge proc.), LL18, LL40 (insect breed), LL49, LL55.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

promote organic fertiliser availability. Job creation and reduction in extra hours appears to be site dependent. A few technologies could introduce new hazards, but most are controllable.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 34

Short title (in English)

PA34: Life cycle assessment of black soldier fly rearing on agricultural residues

Short summary for Practitioners (in English)

A life cycle assessment study evaluated the environmental impacts of insect production based on agro-residues with soybean meal and fishmeal as protein sources.

Given their nutritional value and ability to convert agro-residues into fertilisers, the larvae of Black Soldier Fly may foster nutrient recycling and feedstuff production within the EU on less land than current practices. However, BSF originate from the tropics and their rearing in Europe requires substantial heating and diets composed solely of residues rarely meet their dietary requirements and additional feed is needed.

Both heating and non-residue feed are environmental hotspots of insect production and cause great impacts on fossil resource and water use, and climate change. Overall, insect protein had greater impacts than protein from soybean meal or fishmeal unless location and/or heating source are changed.

Since non-residue feed inputs are needed, insect production based on endive roots and Brussels sprout stems performed worse than their natural degradation on agricultural fields. For manure, BSF production showed advantages due to avoidance of industrial composting and field application, but a clear superiority could not be demonstrated.

Using renewable source instead of natural gas for heating decreased impacts but for non-manure diets such switch was insufficient. Transferring BSF production to warmer regions where no heating is needed could be a more promising option.

Short title (native language)

Levenscyclusanalyse van het kweken van zwarte soldaatvliegen op landbouwresiduen

Short summary for Practitioners (native language)

Een levenscyclusanalyse (LCA)-studie evalueerde de milieueffecten van insectenproductie op agro-residuen (andijviewortels, spruitstengels en dikke fractie varkensmest) met sojameel en vismeel als eiwitbronnen.

Gezien hun voedingswaarde en het vermogen om landbouwresiduen om te zetten in meststoffen, kunnen de larven van de zwarte soldaatvlieg (BSF) (Hermetia illucens) de recycling van nutriënten en de productie van voedermiddelen binnen de EU bevorderen op minder land dan de huidige praktijk.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

BSF is echter afkomstig van de onderwerpen en hun kweek in Europa vereist aanzienlijke verwarming en diëten die uitsluitend uit residuen bestaan, voldoen zelden aan hun voedingsbehoeften en er is aanvullend voer nodig. Zowel verwarming als niet-residuvoer zijn ecologische hotspots van insectenproductie en hebben grote gevolgen voor het gebruik van fossiele hulpbronnen en water, en voor klimaatverandering. Over het algemeen had insecteneiwit een grotere impact dan eiwit uit sojameel of vismeel, tenzij de locatie en/of verwarmingsbron werd gewijzigd.

Omdat voer zonder residuen nodig is, presteerde de insectenproductie op basis van andijviewortels en stengels van spruitjes slechter dan hun conventionele behandeling. Voor mest vertoonde BSF-productie voordelen door het vermijden van conventionele compostering en veldtoepassing, maar een duidelijke superioriteit kon niet worden aangetoond.

Het gebruik van hernieuwbare bronnen in plaats van aardgas verminderde de impact, maar voor diëten zonder mest was een dergelijke omschakeling onvoldoende. Een andere optie zou kunnen zijn om BSF te produceren in warmere streken waar geen verwarming nodig is.

Results (in English)

Soybean meal and fishmeal protein outperformed insect larvae fed on non-manure based diets in all and underperformed manure-based diets in some environmental impact categories.

The greatest environmental impacts were caused by natural gas use for heating in all diets and non-residue diet provision for non-manure-based diets. Switching to alternative heat sources reduced impacts of manure-based insect production below that of soy and fish, but in non-manure-based diets, a switch was insufficient.

Potato starch had the greatest impact contributions to non-residue diet provision and switching to by-products from the potato processing industry was insufficient for the larvae to compete with soy or fish.

Results (native language)

Soja- en viseiwit presteerden in alle opzichten beter dan insectenlarven die gevoed werden met diëten die niet op mest waren gebaseerd, en presteerden ondermaats op diëten op basis van mest in sommige impactcategorieën door het vermijden van de conventionele behandeling van varkensmest.

De grootste milieueffecten werden veroorzaakt door aardgasgebruik voor verwarming in alle rantsoenen en rantsoenvrijvoer voor niet-mestgebonden voeders.

Door over te schakelen op alternatieve warmtebronnen werd de impact van op mest gebaseerde insectenproductie verminderd tot onder die van soja en vis, maar in niet op mest gebaseerde diëten was een overstap onvoldoende.

Aardappelzetmeel had de grootste impact op de voedselvoorziening zonder residuen en het overschakelen op bijproducten van de aardappelverwerkende industrie was onvoldoende voor de larven om te concurreren met soja of vis.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 35

Short title (in English)

PA35: Life cycle assessment of constructed wetlands and duckweed ponds for treating liquid manure

Short summary for Practitioners (in English)

Life cycle assessment (LCA) was applied to evaluate duckweed ponds and constructed wetlands as polishing steps in pig manure liquid fraction treatment. Using nitrification-denitrification (NDN) of the liquid fraction as the starting point, the LCA compared direct land application of the NDN effluent with different combinations of duckweed ponds, constructed wetlands and discharge into natural waterbodies.

Duckweed ponds and constructed wetlands are viewed as a viable tertiary treatment option and potential remedy for nutrient imbalances in areas of intense livestock farming, such as in Belgium. As the effluent stays in the duckweed pond, settling and microbial degradation reduce the remaining phosphorous (P) and nitrogen (N) concentrations. Combined with duckweed and/or wetland plants that take up nutrients in their plant body, this approach can reduce over-fertilisation of soils and prevent excessive N and P losses to aquatic environments. In addition, duckweed could serve as an alternative livestock feed and replace imports of protein destined for animal consumption.

Short title (native language)

Levenscyclusanalyse van aangelegde moerassen en eendenkroosvijvers voor de behandeling van vloeibare mest

Short summary for Practitioners (native language)

Levenscyclusanalyse (LCA) werd toegepast om eendenkroosvijvers en aangelegde moerassen te evalueren als zuiveringsstappen bij de behandeling van vloeibare mestfracties van varkens. Uitgaande van nitrificatie-denitrificatie (NDN) van de vloeibare fractie als vertrekpunt, vergeleek de LCA rechtstreekse toepassing van het NDN-effluent op land met verschillende combinaties van eendenkroosvijvers, aangelegde moerassen en lozing in natuurlijke waterlichamen.

Eendenkroosvijvers en aangelegde moerassen worden beschouwd als een haalbare tertiaire zuiveringsoptie en potentieel middel tegen voedingsstoffenonevenwichtigheden in gebieden met intensieve veehouderij, zoals in België. Omdat het effluent in de eendenkroosvijver blijft, verminderen bezinking en microbiële afbraak de resterende concentraties fosfor (P) en stikstof (N). Gecombineerd met eendenkroos en/of moerasplanten die voedingsstoffen opnemen in hun plantlichaam, kan deze aanpak overbemesting van bodems verminderen en overmatig verlies van N en P naar wateromgevingen voorkomen. Bovendien zou eendenkroos kunnen dienen als alternatief veevoer en import van eiwitten bestemd voor dierlijke consumptie kunnen vervangen.

Results (in English)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

The results suggested that the impact categories most affected were freshwater ecotoxicity (beneficial impacts), climate change (harmful impacts) and minerals and metals resource use potential (harmful in some scenarios and beneficial in others). Generally, duckweed replacement of soybean did not seem to lead to noticeable environmental benefits.

However, the environmental performance of the overall treatment systems studied was found to depend particularly on assumptions about the possible avoidance of potassium (K) fertiliser production through the field application of the K-rich effluents. If assumed that the K contained in the effluent replaces mineral fertiliser, direct field application of the NDN effluent performed best. If the application of NDN effluent does not lead to mineral fertiliser savings or if the replaced K fertiliser is of low grade, duckweed ponds seem to be a viable additional step in the manure treatment chain.

Consequently, whenever background concentrations of N and/or P in fields allow for effluent application and K fertiliser substitution, direct application should be favoured over further treatment. If direct land application of the NDN effluent is not an option, the focus should be on long residence times in duckweed ponds to allow for maximum nutrient uptake and animal feed production.

Results (native language)

De resultaten suggereren dat de meest beïnvloede impactcategorieën zoetwater-ecotoxiciteit (gunstige effecten), klimaatverandering (schadelijke effecten) en het potentieel voor het gebruik van mineralen en metalen (schadelijk in sommige scenario's en gunstig in andere) waren. Over het algemeen leek de vervanging van sojabonen door eendenkroos niet te leiden tot merkbare milieuvoordelen.

De milieu prestaties van de bestudeerde behandelingsystemen bleken echter sterk afhankelijk te zijn van aannames over mogelijke besparingen op kalium (K) kunstmestproductie door het veldgebruik van K-rijke effluenten. Als wordt aangenomen dat het K in het effluent minerale meststof vervangt, presteerde directe veldtoepassing van het NDN-effluent het beste. Als toepassing van het NDN-effluent niet leidt tot besparingen op minerale meststoffen of als de vervangen K-meststof van lage kwaliteit is, lijken eendenkroosvijvers een haalbare extra stap in de mestbehandelingsketen te zijn.Daarom moet, wanneer achtergrondconcentraties van N en/of P op velden toepassing van effluent en vervanging van K-meststof toestaan, directe toepassing de voorkeur krijgen boven verdere behandeling. Als rechtstreekse toepassing van het NDN-effluent op het land geen optie is, moet de focus liggen op langdurige verblijfstijden in eendenkroosvijvers om maximale opname van voedingsstoffen en de productie van diervoeders mogelijk te maken.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 36

Short title (in English)

PA36: Life cycle assessment of pig slurry acidification under Danish natural and regulatory conditions

Short summary for Practitioners (in English)

A life cycle assessment (LCA) study compared the acidification of pig slurry with sulfuric acid in the outdoor storage with no treatment in intensive pig production in Denmark in terms of their environmental performance. Slurry acidification reduces environmental emissions and impacts directly related to the farm, such as emissions of greenhouse gases (mainly methane, CH_4), acidification, eutrophication and fine particulate matter (derived from ammonia, NH_3), but may also contribute to enhanced nutrient recycling overall. However, it can also have harmful effects due to the consumption of additional energy and sulphuric acid manufacturing derived from off-farm resources and increased nitrate leaching due to changed chemical properties of the slurry. To justify slurry acidification as a cleaner production technology on all levels, energy and material sources should be examined and carefully selected. Acidification costs between 7 – 15 DKK / 1 – 2 € per ton of slurry, which can partially be substituted by reduced mineral N fertiliser needs as the slurry fertiliser equivalent value increases by about 30-40%. Since Danish farmers are required to adjust their mineral Nitrogen (N) fertiliser application to the concentration of N in the slurry and a minimum required efficiency, no great differences in yield are to be expected.

Short title (native language)

Livscyklusvurdering af forsuring af svinegylle under danske natur- og reguleringsforhold

Short summary for Practitioners (native language)

En livscyklusvurdering (LCA)-undersøgelse sammenlignede forsuring af svinegylle med svovlsyre i udendørs gylletanke med ingen behandling i intensiv svineproduktion i Danmark med hensyn til deres miljømæssige virkninger. Gylleforsuring reducerer miljøemissioner og -påvirkninger direkte relateret til bedriften, såsom emissioner af drivhusgasser (især metan, CH_4), forsuring, eutrofiering og fine partikler i luften (forårsaget af ammoniak, NH_3). Gylleforsuring kan dog også have skadelige effekter udenfor gården på grund af yderligere energi forbrug og syrefremstilling samt øget nitratudvaskning på grund af ændrede kemiske egenskaber af gyllen. Hvis gylleforsuring skal være en renere produktionsteknologi på alle niveauer bør energi- og materialekilder derfor undersøges og nøje udvælges. Forsuring koster mellem 7 – 15 DKK/t gylle, som delvist kan kompenseres af reduceret mineralsk N-gødningsbehov, da gødningsækvivalentværdien stiger med ca. 30-40%. Den danske miljøregulering kræver at landmændene tilpasser tilførslen af mineralsk N-gødning til koncentrationen af N i gyllen og en mindste krævet gødningseffekt, og der forventes derfor ikke store forskelle i afgrøde udbytte.

Results (in English)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Acidification reduced climate change (global warming potential, GWP), terrestrial acidification (TAP) and fine particulate matter formation (FPMFP); because of lower NH_3 emissions from storage and field application. It increased fossil & mineral resource use, ecotoxicity and human (non-) carcinogenicity; due to sulphuric acid production, the slurry mixing process and market reactions to yield changes. Assuming sulphuric acid to replace sulphur (S) fertiliser or additional soil liming needs to counteract potential soil acidification did not change relative environmental performance of slurry acidification compared to the baseline (no acidification). However, the higher the crop S demand, the lower the additional impact from acidification and farmers could be incentivized to implement slurry acidification instead of direct S fertilization. Given that additional liming needs did not impact relative comparisons, the soil pH status need not be part of decision-making. Acidification outperformed stricter P laws with regards to FPMFP, GWP and TAP. However, materials and energy use increased impacts in other categories. Acidification may shift impacts away from the farm, but local reductions were greater than off-farm increases (e.g. FPMFP, GWP). Marine eutrophication increased locally which may be problematic as the Baltic Sea is a Nitrate Vulnerable Zone.

Results (native language)

Gylleforsuring reducerede global opvarmning (GWP), terrestrisk forsuring (TAP) og dannelse af fine partikler (FPMFP); på grund af lavere emissioner af CH_4 og NH_3 fra gylletank og udbringning i marken. Det øgede fossil- og mineralforbrug, økotoksicitet og menneskelig ikke-karcinogene helbredseffekter; på grund af syreproduktion, blandingsprocessen og markedsreaktioner på udbytteændringer. Hvorvidt gylleforsuring erstatter S-gødskning, og om der er behov for yderligere kalkning for at modvirke potentiel jordforsuring, har dog kun ringe indflydelse på gylleforsuringens miljøeffekt i forhold til basislinjen (ingen gylleforsuring). Men jo højere S behov afgrøderne har, desto lavere er den yderligere påvirkning fra forsuring, og det kan være ekstra incitament for landmanden til at anvende gylleforsuring i stedet for direkte S-gødskning. Da yderligere kalkbehov ikke påvirkede relative sammenligninger, behøver jordens reaktionstal (pH-status) ikke være en del af beslutningstagningen. Ved sammenligning af gylleforsuring med strengere P-udbringnings grænser, syntes gylleforsuring mere gunstig på de samlede miljøeffekter (FPMFP, GWP og TAP). Imidlertid øgede materiale- og energiforbrug i andre kategorier. Forsuring kan resultere i at miljøpåvirkningerne bliver mindre omkring gården, men større andre steder; de lokale reduktioner var dog større end stigninger uden for gården (f.eks. FPMFP, GWP). Eutrofiering af havene steg lokalt, hvilket kan være problematisk, da Østersøen er en nitratfølsomt område.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 37

Short title (in English)

PA37: Life cycle assessment of pig slurry acidification under Dutch natural and regulatory conditions

Short summary for Practitioners (in English)

A life cycle assessment (LCA) study compared the acidification of pig slurry with sulfuric acid in the outdoor storage with no treatment in intensive pig production in the Netherlands in terms of their environmental performance. Slurry acidification reduces environmental emissions and impacts directly related to the farm, such as emissions of greenhouse gases (mainly methane, CH_4), acidification, eutrophication and fine particulate matter (derived from ammonia, NH_3), but may also contribute to enhanced nutrient recycling overall. However, it can also have harmful effects due to the consumption of additional energy and sulphuric acid manufacturing derived from off-farm resources and increased nitrate leaching due to changed chemical properties of the slurry. To justify slurry acidification as a cleaner production technology on all levels, energy and material sources should be examined and carefully selected. Acidification costs between 1 – 2 EUR / t slurry, which can partially be compensated by reduced mineral N fertiliser needs as the fertiliser equivalent value increases by about 30-40%. Since farmers are expected to adjust mineral N fertiliser application to the concentration and ecpected efficiency of N in the slurry, no great differences in yield are to be expected.

Short title (native language)

Levenscyclusanalyse van varkensmestverzuring onder Nederlandse natuurlijke en wettelijke omstandigheden

Short summary for Practitioners (native language)

Een levenscyclusanalyse (LCA) studie vergeleek de verzuring van varkensdrijfmest met zwavelzuur in de buitenbewaring zonder behandeling in de intensieve varkenshouderij in Nederland op hun milieuprestaties. Aanzuring van de drijfmest draagt bij aan een betere recycling van nutriënten in het algemeen en vermindert emissies en effecten die rechtstreeks verband houden met de boerderij, zoals de uitstoot van broeikasgassen (CH4) en fijnstof (NH3). Het kan echter ook schadelijke effecten hebben door de levering van extra energie en zuurproductie afkomstig van bronnen buiten de boerderij en verhoogde nitraatuitspoeling als gevolg van veranderde chemische eigenschappen van de drijfmest. Om verzuring van drijfmest als schonere productietechnologie op alle niveaus te rechtvaardigen, moeten energie- en materiaalbronnen worden onderzocht en zorgvuldig worden geselecteerd. Verzuring kost tussen de 1 en 2 EUR / ton drijfmest, die gedeeltelijk kan worden vervangen door een verminderde behoefte aan minerale N-meststoffen, aangezien de waarde van de meststofequivalent met ongeveer 30-40% toeneemt. Aangezien van boeren wordt verwacht dat zij de minerale N-bemesting aanpassen aan de N-concentratie in de drijfmest, zijn er geen grote opbrengstverschillen te verwachten. Of drijfmestverzuring al dan niet S-bemesting vervangt en of extra bekalking nodig is om mogelijke bodemverzuring tegen te gaan, heeft weinig invloed op de milieuprestaties van drijfmestverzuring ten

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

opzichte van de nulmeting. Echter, hoe hoger de vraag naar S van gewassen, hoe lager de extra impact van verzuring en boeren kunnen gestimuleerd worden om drijfmest aan te zuren in plaats van directe S-bemesting. Aangezien aanvullende kalkbehoeften geen invloed hadden op relatieve vergelijkingen, hoeft de pH-status van de bodem geen deel uit te maken van de besluitvorming. Bij vergelijking van drijfmestverzuring met strengere P-doseringen bleken strengere P-doseringen gunstiger dan invoering van drijfmestverzuring.

Results (in English)

Acidification reduced climate change (global warming potential, GWP), terrestrial acidification (TAP) and fine particulate matter formation (FPMFP); because of lower NH_3 emissions from storage and field application. It increased fossil & mineral resource use, ecotoxicity and human (non-) carcinogenicity; due to sulphuric acid production, the slurry mixing process and market reactions to yield changes. Assuming sulphuric acid to replace sulphur (S) fertiliser or additional soil liming needs to counteract potential soil acidification did not change relative environmental performance of slurry acidification compared to the baseline (no acidification). However, the higher the crop S demand, the lower the additional impact from acidification and farmers could be incentivized to implement slurry acidification instead of direct S fertilization. Given that additional liming needs did not impact relative comparisons, the soil pH status need not be part of decision-making. When comparing slurry acidification against stricter P application rates, stricter P application rates seemed more favourable than the introduction of slurry acidification. Overall, stricter P laws outperformed acidification environmental. In the categories FPMFP and TAP, acidification can supplements stricter P laws. Acidification may shift impacts away from the farm, but local reductions were greater than off-farm increases (e.g. FPMFP, GWP). Marine eutrophication increased locally which may be problematic as the Netherlands are a Nitrate Vulnerable Zone.

Results (native language)

Verzuring verminderde de opwarming van de aarde (GWP), de verzuring van de aarde (TAP) en de vorming van fijn stof (FPMFP); vanwege lagere opslag- en veldtoepassingsemissies. Het verhoogde het gebruik van fossielen en mineralen, de ecotoxiciteit op het land en de kankerverwekkendheid bij de mens; door zuurproductie, het mengproces en marktreacties op opbrengstveranderingen. Ervan uitgaande dat zwavelzuur de S-meststof zou vervangen of aanvullende bodembekalking nodig had, veranderde de relatieve resultaten niet. Over het algemeen presteerden strengere P-wetten beter dan milieuverzuring. In de categorieën FPMFP en TAP kan verzuring een aanvulling zijn op strengere P-wetten. Verzuring kan de impact van de boerderij weghalen, maar lokale reducties waren groter dan toenames buiten de boerderij (bijv. FPMFP, GWP). Mariene eutrofiëring nam plaatselijk toe, wat problematisch kan zijn aangezien Nederland een nitraatgevoelige zone is.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 38

Short title (in English)

PA38: Life cycle assessment of pig slurry acidification under Spanish natural and regulatory conditions

Short summary for Practitioners (in English)

A life cycle assessment (LCA) study compared the acidification of pig slurry with sulfuric acid in the outdoor storage with no treatment in intensive pig production in Denmark in terms of their environmental performance. Slurry acidification reduces environmental emissions and impacts directly related to the farm, such as emissions of greenhouse gases (mainly methane, CH_4), acidification, eutrophication and fine particulate matter (derived from ammonia, NH_3), but may also contribute to enhanced nutrient recycling overall. However, it can also have harmful effects due to the consumption of additional energy and sulphuric acid manufacturing derived from off-farm resources and increased nitrate leaching due to changed chemical properties of the slurry. To justify slurry acidification as a cleaner production technology on all levels, energy and material sources should be examined and carefully selected. Acidification costs between 1 – 2 € per ton of slurry, which can partially be substituted by reduced mineral N fertiliser needs as the slurry fertiliser equivalent value increases by about 30-40%. Since farmers are expected to adjust their mineral Nitrogen (N) fertiliser application to the concentration and expected efficiency of N in the slurry, no great differences in yield are expected.

Short title (native language)

Evaluación del ciclo de vida de la acidificación de purines porcinos en condiciones naturales y reglamentarias españolas

Short summary for Practitioners (native language)

Un estudio de evaluación del ciclo de vida (ACV) comparó la acidificación del purín de cerdo con ácido sulfúrico en el almacenamiento al aire libre con ningún tratamiento en la producción intensiva de cerdos en Dinamarca en términos de su desempeño ambiental. La acidificación del purín reduce las emisiones ambientales y los impactos directamente relacionados con la explotación, como las emisiones de gases de efecto invernadero (principalmente metano, CH4), la acidificación, la eutrofización y las partículas finas (derivadas del amoníaco, NH3), pero también puede contribuir a un mejor reciclaje de nutrientes en general. . Sin embargo, también puede tener efectos nocivos debido al consumo de energía adicional y a la fabricación de ácido sulfúrico derivado de recursos no agrícolas y al aumento de la lixiviación de nitratos debido al cambio de las propiedades químicas del lodo. Para justificar la acidificación de los purines como una tecnología de producción más limpia en todos los niveles, se deben examinar y seleccionar cuidadosamente las fuentes de energía y materiales. La acidificación cuesta entre 1 y 2 euros por tonelada de purín, lo que puede sustituirse parcialmente con menores necesidades de fertilizantes N minerales, ya que el valor equivalente del fertilizante en purín aumenta aproximadamente entre un 30 y un 40 %. Dado que se espera que los agricultores ajusten su aplicación de fertilizantes minerales de

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

nitrógeno (N) a la concentración y eficiencia esperada del N en el purín, no se esperan grandes diferencias en el rendimiento.

Results (in English)

Acidification reduced climate change (global warming potential, GWP), terrestrial acidification (TAP) and fine particulate matter formation (FPMFP); because of lower NH_3 emissions from storage and field application. It increased fossil & mineral resource use, ecotoxicity and human (non-) carcinogenicity; due to sulphuric acid production, the slurry mixing process and market reactions to yield changes. Assuming sulphuric acid to replace sulphur (S) fertiliser did not change relative environmental performance of slurry acidification compared to the baseline (no acidification). While is it not very common to apply S fertiliser, the effect of slurry acidification as alternative to S fertilisation was still tested and it was found that it had little impact on the environmental performance of slurry acidification against the baseline. However, the higher the demand in S of crops (for example maize), the lower the additional impact from acidification and farmers could be incentivized to implement slurry acidification instead of direct S fertilization. Additional liming needs to counteract potential soil acidification did not impact relative comparisons, so the soil pH status need not be part of decision-making. Acidification outperformed stricter P laws with regards to FPMFP, GWP and TAP. However, materials and energy use increased impacts in other categories. Acidification may shift impacts away from the farm, but local reductions were greater than off-farm increases (e.g. FPMFP, GWP).

Results (native language)

La acidificación redujo el calentamiento global (GWP), la acidificación terrestre (TAP) y la formación de partículas finas (FPMFP); debido a las menores emisiones de almacenamiento y aplicaciones de campo.

Aumentó el uso de fósiles y minerales, la ecotoxicidad terrestre, la eutrofización y la carcinogenicidad humana; debido a la producción de ácido, el proceso de mezcla y las reacciones del mercado para producir cambios.

Asumir que el ácido sulfúrico reemplace el fertilizante S tiene un impacto pequeño en los resultados generales. La acidificación puede alejar los impactos de la finca, pero las reducciones locales fueron mayores que los aumentos fuera de la finca (por ejemplo, FPMFP, GWP).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 39

Short title (in English)

PA39: Use of poultry manure compost and pig slurry to replace mineral fertilizers used as basal fertilization in maize crop

Short summary for Practitioners (in English)

Portuguese Farmers need some evidence that mineral fertilizer can “safely” be replaced by organic fertilizers, namely by manure-based fertilizers. Some issues regarding the management and application of such materials need to be clarified/evidenced to farmers namely: 1) The impact on soil health; 2) The impact on weed development; 3) The mineral fertilizer replacement potential; and (iv) The ability of these materials to increase soil organic matter (SOM) content. The potential use of poultry manure compost and pig slurry to replace mineral fertilizers as basal fertilization in maize crop was tested in a commercial Farm located at Azinhaga (Quinta da Cholda – Portugal) in three contrasting sites: site 1) a sandy soil with low organic matter content, submitted to regular application of compost and conventional agriculture practices; site 2) a loamy soil with medium soil organic matter content, no application of organic materials and conventional agriculture practices; and site 3) sandy loam soil under no-tillage practice over the last 15 years. At each site, basal nitrogen fertilization using mineral fertilizers was replaced by pig slurry or poultry compost application. Greenhouse gases emissions were measured during maize growth and the crop yield, nutrient recovery and soil health were assessed at the end of the experiment.

The maize yields obtained in the three sites in plots fertilized with pig slurry or poultry manure were all similar or higher than those obtained with mineral fertilization. However, the use of compost led to an increase of nitrous oxide, one of the stronger GHG.

Short title (native language)

Utilização de estrume de aves compostado e chorume de suínos em substituição de adubos minerais utilizados na fertilização basal da cultura do milho

Short summary (native language)

Os agricultores portugueses precisam de evidências de que os fertilizantes minerais podem ser substituídos de forma segura por fertilizantes orgânicos, nomeadamente fertilizantes à base de estrume. Algumas questões relacionadas com a gestão e aplicação desses materiais precisam de ser esclarecidas/provadas aos agricultores, nomeadamente: 1) O impacto na saúde do solo; 2) O impacto no desenvolvimento de infestantes; 3) O potencial de substituição de fertilizantes minerais; e (iv) A capacidade desses materiais para aumentar o teor de matéria orgânica do solo (SOM). Foi testado o uso potencial de estrume de aves compostado e chorume de porco para substituir os adubos minerais na fertilização basal da cultura do milho numa exploração comercial localizada na Azinhaga (Quinta da

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

Cholda - Portugal) em três solos contrastantes: local 1) um solo arenoso com baixo teor de matéria orgânica, submetido a aplicação regular de compostado e práticas agrícolas convencionais; local 2) um

solo limoso com teor médio de matéria orgânica no solo, sem aplicação de materiais orgânicos e práticas agrícolas convencionais; e local 3) solo franco-arenoso sob prática de sementeira direta nos últimos 15 anos. Em cada local, a fertilização azotada de fundo utilizando adubos minerais foi substituída pela aplicação de chorume de porco ou estrume de aves compostado. As emissões de gases de efeito de estufa foram medidas durante o crescimento do milho e a produtividade da cultura, a recuperação de nutrientes e a saúde do solo foram avaliadas no final do ensaio.

As produções de milho obtidas nos três locais nas parcelas fertilizadas com chorume de porco ou estrume de aves compostado foram todas semelhantes ou superiores às obtidas com fertilização mineral. No entanto, o uso de estrume de aves compostado levou a um aumento das emissões de óxido nitroso, um potente gás com efeito de estufa.

Results (in English)

The present experiment gave clear evidence to farmers of the benefits and limitations related with the use of organic fertilizers for maize fertilization.

It fully contributes to close the N, C, P loops:

- N: close to 30% of the mineral N fertilizer is replaced by a new source of organic N and close the loop of the slurry and compost N by producing some cereals that can be used to feed pigs and poultry.
- C: Both compost and slurry contain a significant amount of organic matter that will enrich the soil. Increasing the quantity of organic matter in soil has the positive effect of increase soil fertility and overall soil health.
- P: Even if the organic fertilizers were applied based on their total N content, they will also provide some P to the soil, ensuring the closure of the slurry and compost P cycles, reducing the inputs of mineral P fertilizer.

Results (native language)

O presente ensaio forneceu evidências claras aos agricultores sobre os benefícios e limitações relacionados com o uso de fertilizantes orgânicos para a fertilização do milho. Esta prática contribui para fechar os ciclos de aztoto, carbono e fósforo:

- N: cerca de 30% do fertilizante mineral azotado é substituído por uma nova fonte de N orgânico e fecha o ciclo do N do chorume e do compostado, produzindo cereais que podem ser usados para alimentar porcos e aves.
- C: tanto o composto como o chorume contêm uma quantidade significativa de matéria orgânica que enriquecerá o solo. O aumento da quantidade de matéria orgânica no solo tem o efeito positivo de aumentar a fertilidade do solo e a saúde geral do solo.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

- P: Mesmo que os fertilizantes orgânicos tenham sido aplicados com base no seu teor total de N, eles também fornecerão algum P ao solo, garantindo o fecho dos ciclos de P do chorume e do compostado, reduzindo a entrada de fertilizante mineral de P.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 40

Short title (in English)

PA40: Ammonia recovery from raw pig slurry in a vacuum evaporation field pilot plant

Short summary for Practitioners (in English)

Livestock manure is typically applied to cropland when it is generated in an amount that fits the farm's land nutrient needs. But when it is produced in excess, livestock manure will need to be exported and/or treatment due to its high and concentration of nutrients, such as nitrogen. Ammonia recovery from livestock manure can produce fertilisers as marketable products and allows for nitrogen loop closure. This particular lighthouse demo investigation develops low temperature vacuum evaporation for the recovery of ammonia from pig slurry, to obtain a salt solution that can be used as a fertiliser. A vacuum evaporation plant (Ammoneva®) has been placed and operated in a farm of UPB Genetic World, S.L. (Viver i Serrateix, Barcelona, Spain). The field pilot plant consists of a solid-liquid separator, a 6.4 m^3 vacuum evaporator, a liquid ring vacuum pump, and an acid trap. After a solid liquid separation, and prior entering the evaporator, the pH value of liquid fraction (LF) of pig slurry is modified to a range of 9-11. Each evaporation cycle lasts for 4 hours, and is performed at a temperature of 40-45 °C and 800 mbar of vacuum. Ammonia evaporated from the LF is conducted to the acid trap, where it is absorbed as an ammonium solution, and a LF with low ammonia content is obtained.

Short title (native language)

Recuperació d'amoníac de purins porcins en una planta d'evaporació al buit

Short summary (native language)

Els purins s'apliquen normalment a les terres de conreu quan es generen en una quantitat que s'ajusta a les necessitats de nutrients de la terra de la granja. Però quan es produeix en excés, els purins s'han d'exportar i/o tractar degut al seu alt contingut en de nutrients, com el nitrogen. La recuperació d'amoníac dels purins pot produir fertilitzants com a productes comercialitzables i així tancar el cicle del nitrogen. La present investigació demostrativa desenvolupa l'evaporació al buit a baixa temperatura per a la recuperació d'amoníac de purins de porc, per obtenir una solució amoniacal que es pugui utilitzar com a fertilitzant. S'ha operat una planta d'evaporació al buit (Ammoneva) en una granja d'UPB Genetic World, S.L. (Viver i Serrateix, Barcelona, Espanya). La planta pilot consta d'un separador sòlid-líquid, un evaporador de 6,4 m^3, una bomba de buit d'anell líquid i una trampa d'àcid. Després d'una separació sòlid-líquid i abans d'entrar a l'evaporador, el valor de pH de la fracció líquida (FL) de purins de porc es modifica a un rang de 9-11. Cada cicle d'evaporació té una durada de 4 hores, i es realitza a una

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

temperatura de 40-45 °C i 800 mbar de buit. L'amoníac evaporat de la FL es condueix a la trampa d'àcid, on s'absorbeix en forma d'una solució d'amoni, i s'obté una FL amb baix contingut en amoníac.

Results (in English)

The treated LF contains on average 41% of the nitrogen content in raw pig slurry, while 15% of nitrogen is recovered in the ammonia solution in the acid trap and 4% is retained in de solid fraction. This way, the need for land for pig slurry application is reduced, and the recovered ammonium solution can be marketed. Due to the plant simplicity, it is suitable to become an on-farm treatment for decentralised pig slurry management. Besides, compared to conventional ammonia stripping and absorption, vacuum evaporation operates at a lower energy cost, as a result of lower heating requirement.

Results (native language)

La FL tractada conté de mitjana un 41% del contingut del nitrogen en purins de porc fresc, mentre que el 15% del nitrogen es recupera en la solució d'amoníac a la trampa àcida i el 4% es reté en la fracció sòlida. D'aquesta manera, es redueix la necessitat de terres per a l'aplicació de purins de porc i es pot comercialitzar la solució d'amoni recuperada. A causa de la senzillesa de la planta, és adequada per convertir-se en un tractament a la granja per a la gestió descentralitzada de purins de porc. A més, en comparació amb el stripping i absorció d'amoníac convencionals, l'evaporació al buit funciona amb un cost energètic més baix, com a resultat d'un menor requeriment d'escalfament.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 41

Short title (in English)

PA41: 3R upcycling process for BIO-NPK-C compound biofertilizers to create user benefits

Short summary for Practitioners (in English)

Phosphorus is industrially upcycled from the renewable food grade animal bone meal unexploited biomass that is converted into macroporous and economically high nutrient density “ABC” Animal Bone Char BioPhosphate. Unique zero emission/energy independent innovative 3R pyrolysis process applied that has been specifically developed to upcycle animal bone meal by-products to make ABC. In the second processing step the blank ABC is biotech formulated into multi-nutrient compound BIO-NPK-C biofertilizer commercial products with multifunctional character and combined with other bio-origin nutrient sources. This is a high added value transformation of unexploited biomass into new and lawful biofertilizer products at less cost, perceived to be of greater quality and environmental/climate value with second life/new function that finished product becomes more practical and valuable than what it previously was. The 3R is aiming to replace in significant industrial scale the imported, energy intensive, chemically processed and non-renewable mineral compound fertilizers, which supply chain/security is disrupted for long term by the new 2023 energy and geopolitical situation. ABC targets agri food crop producer users with demands for environmental friendly and efficient BIO-NPK-C compound formulated bio-based fertilisers to be market competitive, resilient and adaptive to wide range of different climatic/soil applications at less cost. Lawfulness demonstrated, EU REACH certified, MS Authority permitted for commercial applications while EU 2019/1009 EC fertilizer conformity pre-audited to meet different product functional category requirements to create multiple financial and non-financial benefits for the users.

Short title (native language)

3R újrahasznosítási eljárás a BIO-NPK-C biotápanyag előállítására és felhasználói előnyök létrehozására

Short summary (native language)

A foszfor újrahasznosítása megújuló élelmiszer-minőségű állati csontlisztből mint kiaknázatlan biomasszából történik, melyet makropórusos és gazdaságosan magas tápanyag sűrűségű ABC állati csontszén Biofoszfáttá alakítanak. Egyedülálló, zéró emisszió/energia független innovatív 3R pirolízis eljárást alkalmaz, melyet kifejezetten az állati csont melléktermékek újrahasznosítására fejlesztettek ki. A második lépésben az ABC-t biotechnológiai eljárással többfunkciós karakterű BIO-NPK-C termékekké alakítják és más bio-tápanyagforrásokkal kombinálnak. Ez a kiaknázatlan biomassza magas hozzáadott értékű és gazdaságos átalakítása új és törvényes biotrágya termékekké, jobb minőséget és környezetvédelmi/klímaértéket képvisel, második élettel/új funkcióval, mely által késztermék

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

értékesebb, mint amilyen korábban volt. A 3R jelentős ipari méretben kívánja kiváltani az importált, energiaigényes, kémiai úton feldolgozott nem megújuló műtrágyákat, amelyek ellátási láncát/biztonságát hosszú távon megzavarta a 2023-as új energetikai és geopolitikai helyzet. Az ABC a mezőgazdasági élelmiszernövény-termelőket célozza meg, akik környezetbarát és hatékony BIO-NPK-C összetett tápanyagokat igényelnek, hogy versenyképesek, rugalmasak legyenek és alkalmazkodni tudjanak az eltérő éghajlati/talaji viszonyokhoz. Az eljárás törvényi megfelelősége igazolt, EU REACH tanúsítvánnyal rendelkezik, valamint tagállami hatósági forgalomba hozatali engedélye van, míg az EU 2019/1009 rendeletének történő megfelelőségét előzetesen auditálták, a különböző termék-funkcionális kategóriák követelményei szerint, ezáltal a felhasználók számára többféle gazdasági és nem anyagi előnyt biztosítanak.

Results (in English)

Economically high nutrient density BioPhosphate is upcycled from food grade animal bone meal unexploited biomass, converted into macroporous “ABC” Animal Bone Char. Zero emission/energy independent novel 3R pyrolysis process applied to make ABC that is formulated into multifunctional and controlled release compound BIO-NPK-C biofertilizer to create multiple financial and non-financial benefits for the users. EU/MS regulations applied. The BioPhosphate is in regional scale at 2 kt/y capacity, scale up with 20 kt/y expected by 2024. The application dose of the BIO-NPK-C compound formulated commercial product is between 200 kg/h to 500 kg/ha and available in 3-5 mm pellet/granulated sizes.

Results (in native language)

A gazdaságosan magas tápanyag sűrűségű Biofoszfát újrahasznosítása élelmiszer-minőségű állati csontlisztből (kiaknázatlan biomassza) történik melyet makropórusos „ABC” csontszénné alakítanak. Az ABC előállítása innovatív 3R zéró emissziós/energiafüggetlen pirolízis eljárással történik. Többfunkciós/szabályozott hatóanyag-leadású BIO-NPK-C biotrágyát állítanak elő mely többszörös gazdasági és nem anyagi előnyöket teremt a felhasználóknak. EU/tagállami előírásoknak megfelel. A Biofoszfát regionális kapacitása 2 kt/év, mely 2024-re várhatóan 20 kt/év-re bővül. A BIO-NPK-C termék alkalmazási dózisa 200-500 kg/ha. 3-5 mm-es pellet/granulált méretben kapható.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 42

Short title (in English)

PA42: Microalgae cultivation in digestate for sustainable and local protein production

Short summary for Practitioners (in English)

Microalgae are small photosynthetic organisms, which means they can produce their own organic carbon from CO2. These organisms are much more efficient in capturing CO2 from the atmosphere than conventional crops, and therefore have a higher potential for mitigation of greenhouse gas emissions.

Besides CO2, microalgae require N, P, K and other macro and micronutrients, which can be provided in the form of liquid fraction of digestate, creating value from it. However, the liquid fraction of digestate has high ammonia concentration and high turbidity, which can hinder microalgae growth.

To address these challenges, the Nutri2Cycle project evaluated the growth of microalgae on digestate on a pilot scale 500 L photobioreactor installed in a greenhouse in Belgium. Filtration, dilution and fed-batch strategies were tested to improve the quality of the digestate for microalgae cultivation.

Short title (native language)

Microalgen kweken in digestaat voor duurzame en lokale eiwitproductie

Short summary (native language)

Microalgen zijn kleine fotosynthetische organismen, wat betekent dat ze hun eigen organische koolstof kunnen produceren uit CO2. Deze organismen zijn veel efficiënter in het vastleggen van CO_2 uit de atmosfeer dan conventionele gewassen en hebben daarom een groter potentieel voor het verminderen van de uitstoot van broeikasgassen.

Naast CO2 hebben microalgen N, P, K en andere macro- en micronutriënten nodig, die kunnen worden geleverd in de vorm van de vloeibare fractie van digestaat, waardoor er waarde wordt gecreëerd. De vloeibare fractie van digestaat heeft echter een hoge ammoniakconcentratie en een hoge troebelheid, wat de groei van microalgen kan belemmeren.

Om deze uitdagingen aan te pakken, evalueerde het Nutri2Cycle-project de groei van microalgen op digestaat in een fotobioreactor van 500 L op proefschaal in een kas in België. Filtratie, verdunning en fed-batch strategieën werden getest om de kwaliteit van het digestaat voor de kweek van microalgen te verbeteren.

Results (in English)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Digestate was a good source of nitrogen for microalgae cultivation. However, some nutrient supplementation might be necessary for healthy algae growth.

Microfiltration (< 0.2 µm) of digestate is not recommended, as important nutrients were lost. A coarse filtration (> 10 µm) was enough to remove bigger particles and maintain good levels of nutrients. Nevertheless, other pore sizes might be more suited depending on the digestate.

When using high-strength digestate (ammonia concentration around 3000-5000 mg/L), a high dilution is needed to meet the 50 mgN/L limit in the medium. Feeding of additional digestate during algae growth can be done to achieve the final concentrations of around 2 g/L of dry weight algae biomass. Batch cultures can take around 7 days to achieve this final concentration, but it is possible to operate the reactor in a semi-continuous way so that about 50% of the reactor volume is harvested daily.

More research is needed to reduce the water footprint of the system, either by optimization of the cultivation protocol or by recirculating the cultivation water for several cycles.

Results (native language)

Digestaat was een goede bron van stikstof voor de kweek van microalgen. Aanvulling met voedingsstoffen kan echter nodig zijn voor een gezonde algengroei.

Microfiltratie (< 0,2 µm) van digestaat wordt niet aanbevolen, omdat er belangrijke voedingsstoffen verloren gingen. Een grove filtratie (> 10 µm) was voldoende om grotere deeltjes te verwijderen en goede niveaus van voedingsstoffen te behouden. Toch kunnen andere poriegroottes geschikter zijn, afhankelijk van het digestaat.

Bij gebruik van digestaat met een hoge sterkte (ammoniakconcentratie rond 3000-5000 mg/L) is een hoge verdunning nodig om de limiet van 50 mgN/L in het medium te halen. Het voeden van extra digestaat tijdens de algengroei kan worden gedaan om de uiteindelijke concentraties van ongeveer 2 g/L algenbiomassa op drooggewicht te bereiken. Batchculturen kunnen er ongeveer 7 dagen over doen om deze eindconcentratie te bereiken, maar het is mogelijk om de reactor semi-continu te laten werken zodat dagelijks ongeveer 50% van het reactorvolume wordt geoogst.

Er is meer onderzoek nodig om de watervoetafdruk van het systeem te verkleinen, ofwel door het kweekprotocol te optimaliseren of door het kweekwater gedurende meerdere cycli te recirculeren.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 43

Short title (in English)

PA43: Findings from bio-based fertiliser trial within an Irish cropland setting

Short title

This Nutri2Cycle trial aimed to return nutrients to croplands & displace some of the crops chemical fertiliser needs by incorporating various bio-based fertilisers into the sites nutrient management plan (NMP).

Short Summary for Practitioners

The trial site, which was located on a working arable farm, was established in 2019 and ran for the duration of the Nutri2Cycle project. The crop rotation consisted of maize silage (2019), spring wheat (2020), oilseed rape (2021), winter wheat (2022) & spring beans (2023). The trial site consisted of seven fertiliser treatment plots, which were zero fertiliser (control), chemical fertiliser (CF) only, and, a further five bio-based fertiliser (BBF) treatments, namely, treatments including cattle slurry, pig slurry solids, poultry manure, and two types of dairy processing sludge (DPS), to supply part of the crops nutrient requirements based on soil test data and targeted yield. These five BBF were analysed to assess both their nutrient value & nutrient availability. As the BBF did not provide all the crops N, P, K and S requirements, these treatments were supplemented or ''balanced'' with CF in order to ensure all plots received the same amount of nutrients for optimal yield. Using available data from 2019 to 2022, several benefits of incorporating BBF into an arable NMP are apparent. Using BBF to recycle nutrients can provide a considerable amount of a crops P requirements, and, in doing so, can reduce the associated fertiliser costs and P imports. In addition, soil data from the trial has shown that BBF can also be used to effectively build soil P and K fertility. In addition, CF only plots and balanced BBF plots returned comparable yields, which indicates that incorporating BBF fertilisers into arable systems could be a financially viable option for crop farmers and a way to reduce the reliance on CF.

Results

The BBF treatments trialled demonstrated a high capacity to displace an arable farmers mineral P requirements. For example, in 2022, winter wheat at the trial site required 32 kg of P per hectare (ha). Poultry manure, pig slurry solids, calcium-precipitated dairy processing sludge (DPS) and aluminium-precipitated DPS provided the winter wheat crop with 100% of its P needs, at application rates of 3.1 tonnes/ha, 1.7 tonnes/ha, 1.1 tonnes/ha and 7 tonnes/ha respectively. Cattle slurry provided 66% of the wheats P needs at an application rate of 33.7 tonnes/ha. Both the cattle slurry and pig slurry solids also provided the entirety of the crops potassium requirements, 110 K kg/ ha. Cattle slurry was unable to provide the crop with all its P needs, as the rate of application required would have supplied an excessive amount of K.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 44

Short title

PA44: Emissions from plasma treated sludge

Short summary for Practitioners (in English)

Application of manure to agricultural soils can improve soil quality and productivity by maintaining its nutrient status and organic matter (OM) content. Resulting nitrogen (N) emissions in the form of ammonia (NH3) and the greenhouse gas nitrous oxide (N2O) may however lead to substantial environmental pressure. Manure plasma activation has been considered an innovative technique that lowers nitrogen losses during and after soil application. The scientific documentation on its effects is still limited.

In 2022 Wageningen Environmental Research (WEnR) conducted a study within Nutri2Cycle project to quantify gaseous losses of NH3 and N2O from plasma activated manure (PAM) and non-treated raw manure (RM) applied to soil.

Short title (native language)

Emissies van plasma behandelde mest

Short summary (native language)

Bemesting van landbouwgronden kan de bodemkwaliteit en -productiviteit verbeteren door de nutriëntenstatus en het gehalte aan organische stof (OM) op peil te houden. De resulterende stikstof (N) emissies in de vorm van ammoniak (NH3) en het broeikasgas lachgas (N2O) kunnen echter leiden tot een aanzienlijke druk op het milieu. Behandeling van mest met plasma wordt aangeprezen als een innovatieve techniek die de stikstofverliezen tijdens en na het opbrengen in de bodem verlaagt. De wetenschappelijke documentatie over de effecten ervan is nog beperkt.

In 2022 heeft Wageningen Environmental Research (WEnR) voor het Nutri2Cycle project een studie uitgevoerd om de gasvormige verliezen van NH3 en N2O uit plasma-geactiveerde mest (PAM) en niet-behandelde ruwe mest (RM) op de bodem te kwantificeren.

Results (in English)

In general, plasma activation caused significant changes in manure characteristics (i.e. Organic Matter degradation, pH, NO3- concentration) affecting gaseous N emissions. At a dose of 170 kg N/ha, PAM showed substantial reduction of NH3 volatilization compared to RM, whereas N2O emissions increased significantly. Manure plasma activation resulted in a decrease of total atmospheric N losses. Still, the observed increase in N2O flux raises the question of the environmental impact of PAM application. In line with the elevated NO3- concentrations, N2O fluxes from PAM started shortly after application, whereas

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

highest fluxes were observed for RM after 7 days only. Altogether, the results show an important tradeoff between NH3 and N2O emissions from these manure products and indicate that PAM may be better used as topdress fertilizer instead of a replacement for RM to maximize plant NO3- uptake and minimize gaseous N losses.

Results (in native language)

In het algemeen veroorzaakte plasma-activering significante veranderingen in mestkarakteristieken (d.w.z. afbraak van organisch materiaal, pH, NO3- concentratie) die de gasvormige N-emissies beïnvloedden. Bij een dosis van 170 kg N/ha vertoonde PAM een aanzienlijke vermindering van NH3-vervluchtiging in vergelijking met RM, terwijl de N2O-emissies aanzienlijk toenamen. Mestplasma-activering resulteerde in een afname van de totale atmosferische N-verliezen. Toch doet de waargenomen toename van de N2O-flux de vraag rijzen naar het milieueffect van de toepassing van PAM. In overeenstemming met de verhoogde NO3- concentraties begon de N2O-flux van PAM kort na de toepassing, terwijl de hoogste fluxen bij RM pas na 7 dagen werden waargenomen. Al met al laten de resultaten een belangrijke wisselwerking zien tussen NH3- en N2O-emissies van deze mestproducten en wijzen ze erop dat PAM beter kan worden gebruikt als bijbemesting in plaats van als vervanging voor RM om de NO3-opname door planten te maximaliseren en gasvormige N-verliezen te minimaliseren.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 45

Short title

PA45: Application of BioBased Fertilizer on potato in sandy soil

Short summary for Practitioners (in English)

Practice Center for Precision Agriculture, Reusel, South Netherlands, tested application of BioBased Fertilizer (BBF) on potato for project Nutri2Cycle in 2022.

Basic fertilization was applied with a standard slurry injector. The test focussed on top dressing with pigmanure; where two issues were addressed: (i) Standard slurry is too heterogenous to do a reliable top dressing. Therefore the Liquid Fraction Dosing (LFD) of pig slurry was used, with a more constant NPK content. Even the thin fraction of pig slurry is difficult to pomp through an application system, it might cause constipation, therefore it was treated with plasma. (ii) Application was done with a trailing hose fertilization device, just before complete canopy coverage. It was expected that this system limits exhaust of fermentation gases, especially ammonia, and reduces the risk of burn marks on leaves.

Short title (native language)

Toepassing van bio-meststoffen op zandgrond

Short summary (native language)

Praktijkcentrum voor Precisielandbouw, Reusel, Zuid-Nederland, testte toepassing van Bio-meststoffen, (BioBased Fertilizer, BBF) op aardappel voor project Nutri2Cycle in 2022.
De basisbemesting werd toegepast met een standaard drijfmestinjector. De test richtte zich op bijbemesting met organische mest, waarbij 3 zaken aan de orde kwamen: (i) Standaard drijfmest is te heterogeen om een betrouwbare bijbemesting te doen. Daarom werd de Liquid Fraction Dosing (LFD) van varkensdrijfmest gebruikt, met een constanter gehalte aan NPK. Zelfs de dunne fractie van varkensdrijfmest is moeilijk door een toepassingssysteem te pompen, het zou verstopping kunnen veroorzaken, daarom werd het behandeld met plasma. (ii) De bemesting werd uitgevoerd met sleepslangen, vlak voordat het gewas volledig sloot. Verwacht werd dat dit systeem de uitstoot beperkt van fermentatiegassen, met name ammoniak, en het risico van brandplekken op bladeren vermindert. Uit dit onderzoek bleek dat BBF's veilig kunnen worden gebruikt in de aardappelteelt op zandgronden.

Results (in English)

This study showed that BBFs can safely be used in potato growing on sandy soils: (i) The LFD was a good basis for application; the plasma treated slurry gave no significant problems with constipation. Still this system is innovative and new problems will occur; (ii)The application with trailing hoses made it possible

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

to apply in covered conditions. However it is not allowed to apply slurry of LFD above soil in the Dutch legislation .

The adoption of BBFs can be stimulated by (i) solving the practical issues that occurred during the application of LFD, (ii) making sure BBFs are on the list of RENURE materials so they can legally replace mineral fertiliser, and reducing the surplus of slurry manure to stimulate the use and fair pricing of BBF products.

Results (native language)

Uit dit onderzoek bleek dat BBF's veilig kunnen worden gebruikt in de aardappelteelt op zandgronden: (i) De LFD was een goede basis voor toepassing; de met plasma behandelde drijfmest gaf geen noemenswaardige problemen met verstopping. Toch is dit systeem innovatief en zullen zich nieuwe problemen voordoen; (ii) De toepassing met sleepslangen maakte het mogelijk om in overdekte omstandigheden toe te passen. Volgens de Nederlandse wetgeving is het echter niet toegestaan om drijfmest van LFD boven de grond toe te passen.

De toepassing van BBF's kan worden gestimuleerd door (i) de praktische problemen op te lossen die zich bij de toepassing van LFD hebben voorgedaan, (ii) ervoor te zorgen dat BBF's op de lijst van RENURE-materialen staan zodat ze wettelijk minerale meststoffen kunnen vervangen, en het overschot aan drijfmest te verminderen om het gebruik en een eerlijke prijsstelling van BBF-producten te stimuleren.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 46

Short title (in English)

PA46: Precision Application of manure in potato

Short summary for Practitioners (in English)

Variable Rate Application (VRA) of pig manure in top dressing fertilization may have a positive effect on the yield of potato. Therefore standard top dressing of chemical fertilizer and evenly spread of 50m3 basic fertilization (April) plus 14m3 top dressing (July) of manure was compared to application in 3 VRA zones: low (25+7m^3) medium (50+14m^3) and high (75+21m^3). Two strategies were tested: more manure on rich soil (high buffering capacity, 'all for the best') and more manure on poor soil ('robin hood').
Soil buffering capacity was assessed by measuring Electrical Conductivity (EC). EC is an indicator for the organic matter content, water-holding capacity and nutrient content. Based on this, 3 field zones were determined: poor (EC 1,6-3,7), medium (EC 1,9-4,0) and rich (EC 2,6-4,8). Per zone, soil was analysed on nutrients (NPK) content.
The growth of the crop was assessed by drone thermal and spectral images, from which different indexes (NDVI, NDRE, VARI, WDVI) were calculated and represented in spatial maps. In addition, manual probe harvests were done on different moments; during the final harvest a yield map was produced. With data of treatment zones, differences in yield were calculated and economic consequences were discussed.

Short title (native language)

Precisie toepassing van mest in aardappel

Short summary (native language)

Variable Rate Application (VRA) van varkensmest in bijbemesting kan een positief effect hebben op de opbrengst van aardappel. Daarom werd standaardbemesting met kunstmest en gelijkmatig uitgereden 50m3 basisbemesting plus 14m3 mest vergeleken met 3 VRA zones: laag (25+7m^3), middel (50+14m^3) en hoog (75+21m^3). Twee VRA-strategieën zijn getest: meer mest op rijke grond (hoge buffercapaciteit, 'all for the best') en meer mest op arme grond ('robin hood').
Het bufferend vermogen van de bodem werd beoordeeld door de elektrische geleidbaarheid (EC) te meten. De EC is een indicator voor het organische stofgehalte, het waterhoudend vermogen en het nutriëntengehalte. Op basis hiervan werden arme (EC1,6-3,7), gemiddelde (EC 1,9-4,0) en rijke (EC 2,6-4,8) veldzones bepaald. Per zone werd de grond geanalyseerd op NPK.

De groei van het gewas werd beoordeeld met dronebeelden, waaruit verschillende indexen (NDVI, NDRE, VARI, WDVI) werden berekend en weergegeven in ruimtelijke kaarten. Daarnaast werden op verschillende momenten handmatige sonde-oogsten uitgevoerd; bij de laatste oogst werd een opbrengstkaart gemaakt. Met gegevens van behandelzones werden verschillen in opbrengst berekend en economische gevolgen zijn doorgesproken.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Results (in English)

The VRA strategies had effect on yield: highest average yield was reached with ‘more manure top dressing on poor soil’ (52,8 tons/ha), which was 3% higher than ‘standard chemical fertilizer’ (51,4) and clearly higher than ‘more manure rich soil’ (48,7) and ‘manure without VRA’ (48,3).
So the VRA application of second fertilisation with manure between the potato ridges gives the best results. However, we see that the total application cost instead of chemical fertilizer has a much higher cost price per treatment zone compared to the standard application of manure before the crops or the application of chemical fertilizer between the crops like it is more standard in the potato growing process nowadays.
In all treatments the same average amount of fertilizer was applied (low dosage compensates for high), so the nutrient efficiency is directly related to the yield: highest efficiency in ‘more manure on poor soil’.

Results (native language)

De VRA strategieën hadden effect op de opbrengst: de hoogste gemiddelde opbrengst werd bereikt met 'meer mest topdressing op arme grond' (52,8 ton/ha), wat 3% hoger was dan 'standaard kunstmest' (51,4) en duidelijk hoger dan 'meer mest rijke grond' (48,7) en 'mest zonder VRA' (48,3). Dus de VRA-toepassing van de tweede bemesting met mest tussen de aardappelruggen geeft de beste resultaten. We zien echter dat de totale toedieningskosten in plaats van kunstmest een veel hogere kostprijs hebben per behandelzone in vergelijking met het standaard toedienen van mest vóór het gewas of het toedienen van kunstmest tussen de gewassen zoals dat tegenwoordig meer standaard is in de aardappelteelt.
In alle behandelingen werd dezelfde gemiddelde hoeveelheid kunstmest toegediend (lage dosering compenseert hoge), dus de nutriëntenefficiëntie is direct gerelateerd aan de opbrengst: hoogste efficiëntie in 'meer mest op arme grond'.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 47

Short title (in English)

PA47: Substituting mineral inputs with organic inputs in organic viticulture

Short summary for Practitioners (in English)

A two-year demonstration was carried out in an organic farm combining field crops and a vineyard. The aim was to decide whether the oil-cake obtained from extracting rapeseed, hemp, sunflower and camelina oil should be used as livestock feed for a neighbouring farm, as was usually done, or as a fertiliser or soil-enhancer with biostimulating effect for the vineyard. During the first year, the fertilising efficiency of the oil-cake was compared to a commercial organic compost and a mix of both. During the second year, the oil-cake was compared to a control plot. The obtained results were mixed. One explanation is that the plots chosen for the demonstration were already showing differences in the soil profile, probably due to differences in sun exposure. Furthermore, legumes had been planted in every second interrow of the vineyard in every plot, which may have biased greatly the N content of some samples. Finally, the varying climatic conditions between the two years of demonstrations may have affected the results. The main recommendation would be to consider the oil-cake as an as effective fertiliser as the commercial compost. More experimentations should be done over more years to confirm these findings.

Short title (native language)

La substitution des intrants minéraux par les intrants organiques en viticulture biologique

Short summary (native language)

Une démonstration de deux ans a été conduite sur une ferme biologique combinant des cultures arables et un vignoble. L'objectif était de décider si le tourteau obtenu par extraction d'huile de colza, de chanvre, de tournesol et de cameline devait être utilisé en tant qu'aliment pour un élevage voisin, comme c'était d'habitude le cas, ou bien comme fertilisant ou améliorateur de sol avec un effet biostimulant pour le vignoble. Durant la première année, l'effet fertilisant du tourteau a été comparé à celui d'un compost biologique commercial et à un mélange des deux. Durant la seconde année, le tourteau a été comparé à une parcelle témoin. Les résultats obtenus ont été mitigés. Une des raisons possibles est que les parcelles choisies pour la démonstration montraient des différences préalablement à la démonstration, probablement en raison de différences d'exposition. De plus, des légumineuses avaient été plantées dans chaque deuxième interrang de chaque parcelle du vignoble, ce qui a pu biaiser le contenu N de certains prélèvements. Enfin, les conditions climatiques variables entre les deux années ont pu affecter les

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

résultats. Plus d'expérimentations sont nécessaires sur un nombre plus important d'années pour confirmer ces résultats.

Results (in English)

Agronomic properties of the oil-cake showed to be similar to those of the commercial compost. However, despite a higher stock of N in the oil-cake plot, the N availability seemed to be lower. The NPK content of the grapevines was higher for the oil-cake plot compared to the compost plot in the first year but similar to the control plot in the second year. The vegetation index was highest for the compost, lowest for the oil-cake and intermediate for the mix during the first year and slightly lower for the oil-cake compared to the control during the second year.

Results (native language)

Les propriétés agronomiques du tourteau se sont montrées similaires à celles du compost commercial. Cependant, malgré un stock d'azote plus élevé dans la parcelle de tourteau, la disponibilité en azote est apparue plus faible. Le contenu NPK des baies était plus élevé pour le tourteau comparé au compost pendant la première année mais similaire au témoin la deuxième année. L'indice de végétation était le plus élevé pour le compost, le plus faible pour le tourteau et intermédiaire pour le mélange des deux la première année, légèrement plus faible pour le tourteau par rapport au témoin la deuxième année.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 48

Short title (in English)

PA48: Circular economy and fertilization: recycling of livestock effluents on agro-forestry plot

Short summary for Practitioners (in English)

As part of the Nutri2Cycle project, the Chamber of Agriculture was asked for demonstrating the situation of nutrient cycling in a farm combining livestock, crops and agroforestry. So we followed from 2019 to 2022 an agroforestry plot at the Manicot farm which combines geese' husbandry and cropping in Charente-Maritime. A 8 ha plot, planted since 2010 with linear intra-plot coppice for the production of energy biomass with, has been monitored on four different areas established according to the spreading of effluents and the agroforestry situation. We observed the effects of the fertilization practices for each zone from 2019 to 2022:

Areas	Surface (ha)	2019	2020	2021	2022
		Winter Wheat	Corn	Corn	Winter Wheat
A	0.956	Slurry + mineral fertilisation	Mineral fertilisation	Slurry + mineral fertilisation	Slurry + mineral fertilisation
B	0.971	Mineral fertilisation	Solid manure + mineral fertilisation	Slurry + mineral fertilisation	Mineral fertilisation
C	1.665	Mineral fertilisation	Mineral fertilisation	Mineral fertilisation	Mineral fertilisation
D	4.744	Mineral fertilisation	Mineral fertilisation	Mineral fertilisation	Mineral fertilisation

The evaluation of the annual stocks of effluents led to a result of 145 m3 of slurry and 25 tons of manure. The contents of NPK elements on raw matter are lower than 0.5% per element: these effluents cannot claim the commercial qualification of fertilizer but they have a fertilizing value at farm.

The four areas were followed mainly using remote sensing associated with analyzes of soil organic matter and tests of nitrogen mineralization kinetics. Observations were cross-referenced with fertilization balance calculations and crop development simulations using the STICS tool designed by INRAe.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Short title (native language)

Economie circulaire et fertilisation : valorisation des effluents d'élevage sur parcelle agro-forestière

Short summary (native language)

Dans le cadre du projet Nutri2Cycle, la Chambre d'agriculture a été sollicitée pour une démonstration du cycle des nutriments sur une exploitation agricole combinant élevage, grandes cultures et agroforesterie. Nous avons ainsi suivi de 2019 à 2022 une parcelle agroforestière à la ferme Manicot qui allie élevage d'oies et culture en Charente-Maritime. La parcelle de 8 ha, plantée depuis 2010 en taillis intra-parcellaire linéaire pour la production de biomasse énergétique, a été divisée en quatre zones différentes selon l'épandage des effluents et la situation agroforestière. Nous avons observé les effets des pratiques de fertilisation pour chaque zone de 2019 à 2022:

Zones	**Surface (ha)**	**2019**	**2020**	**2021**	**2022**
		Blé d'hiver	Maïs	Maïs	Blé d'hiver
A	0.956	lisier + fertilisation minérale	fertilisation minérale	lisier + fertilisation minérale	lisier + fertilisation minérale
B	0.971	fertilisation minérale	fumier + fertilisation minérale	lisier + fertilisation minérale	fertilisation minérale
C	1.665	fertilisation minérale	fertilisation minérale	fertilisation minérale	fertilisation minérale
D	4.744	fertilisation minérale	fertilisation minérale	fertilisation minérale	fertilisation minérale

L'évaluation des stocks annuels d'effluents a abouti à un résultat de 145 m3 de lisier et 25 tonnes de fumier. Les teneurs en éléments NPK sur la matière première sont inférieures à 0,5% par élément : ces effluents ne peuvent prétendre à la qualification commerciale d'engrais mais ils ont une valeur fertilisante à la ferme. Les quatre zones ont été suivies principalement par télédétection associée à des analyses de matière organique des sols et à des tests de cinétique de minéralisation de l'azote. Les observations ont été croisées avec des calculs de bilans de fertilisation et des simulations de développement des cultures grâce à l'outil STICS conçu par l'INRAe.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Results (in English)

The farm's effluents contribute to the fertilization of 4 ha out of 86 ha of cultivated UAA (5%): the fertilization system still depends on external supply.
The available nitrogen supply was estimated at 17% of the total supply for manure and 88% for slurry.
The organic fertility of the soil was assessed with values ranging from 15 to more than 100 kg N/ha.
Soil organic matter fractionation analyzes confirmed the significant share of stable carbon, with a carbon stock evaluated at an average of 36 t/ha.
We observed that there is no negative agronomic effect from intra-plot hedge but on the contrary rather a positive effect.
The farmers have declared their intention to continue their program of planting intra-plot hedges up to 40 ha to achieve energy self-sufficiency.

Results (native language)

Les effluents de l'exploitation contribuent à la fertilisation de 4 ha sur 86 ha de SAU cultivée (5%) : le système de fertilisation dépend toujours d'un apport extérieur.
L'apport d'azote disponible a été estimé à 17 % de l'apport total pour le fumier et à 88 % pour le lisier. La fertilité organique du sol a été évaluée avec des valeurs allant de 15 à plus de 100 kg N/ha.
Les analyses de fractionnement de la matière organique des sols ont confirmé la part importante de carbone stable, avec un stock de carbone évalué en moyenne à 36 t/ha.
Nous avons observé qu'il n'y a pas d'effet agronomique négatif de la haie intra-parcellaire mais au contraire plutôt un effet positif. Les agriculteurs ont déclaré leur intention de poursuivre leur programme de plantation de haies intra-parcellaires jusqu'à 40 ha pour atteindre l'autosuffisance énergétique.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

Practice abstract 49

Short title (in English)

PA49: Using precision technologies in plants nutrient management

Short summary for Practitioners (in English)

Tractor-mounted sensor technologies using the NDVI (normalized difference vegetation index) indicator, such as Yara and Green Seeker, and drone technologies (Unmanned Aerial Vehicles, UAV) can be successfully used in nutrient management. The nutrient supply of plants and the heterogeneity of the plots can be seen indirectly from the data of the field maps made on the basis of the recorded raw data. The satellite communication of the tractor technologies use the 20m x 20m or 10m x 10m grid resolution, while the drone technology uses centimeter- precise information. Since the drones are equipped with positioning device, multi-spectral and thermal cameras, they can be used even in cloudy or unstable weather conditions, can adapt to the local conditions, and provide real-time information at a relatively low cost. They can be successfully applied to heterogeneous crops such as grapes and orchards. The results of the tests carried out within the Nutri2Cycle project showed that drone technology offers more perspectives than the tractor mounted sensor technology because a) their use can be easily learned by farmers b) there are several types of software available for raw data processing, b) the information can be made compatible with the automatic control of tractors, c) the processed data can be used also for spraying, and by determining the evapo-transpiration index in yield estimation, in irrigation and in evaluating the crops carbon sequestration potential, but also in the variable rate of sowing. Lately, farmers are constantly switching from the tractor sensor technology to the drone technology.

Short title (native language)

Precíziós eljárások alkalmazása a tápanyag gazdálkodásban

Short summary (native language)

Az NDVI (normalised difference vegetation index) mutatót alkalmazó traktorra szerelt szenzortechnológiák, mint a Yara és Green Seeker és a nagy perspektívákat mutató dróntechnológiák (Unmaned Aerial Vehicles, UAV) sikeresen alkalmazhatók a tápanyag-gazdálkodásban. A felvételezett nyers adatok alapján készült tábla térképek adataiból közvetett módón válik láthatóvá a növények tápanyag-ellátottsága és a terület heterogenitása is. A traktor techológiák műholdas kommunikációja a 20m x 20m vagy a 10m x 10m rácsos felbontást alkalmazzák, míg a dróntechnológia centiméter pontos információkat. Mivel a drónok helymeghatározó eszközzel, multi spektrális és hő kamerákal vannak felszerelve felhős vagy változó időjárási körülmények között is használhatók, alkalmazkodnak a területi viszonyokhoz és valós idejű információkat szolgáltatnak relatív alacsony költséggel. Sikeresen alkalmazhatók heterogén növényeknél mint a szőlő és gyümölcsültetvények is. Az elvégzett tesztek eredményei azt mutatják, hogy a dróntechnológia a traktorra szerelt szenzortechnológiával szemben

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

több perspektívát mutat ugyanis a) használatuk a gazdák által könnyen elsajátítható b) az adatfeldolgozáshoz többféle szoftver áll rendelkezésre, b) az információk kompatibilissé tehetők a traktorok automata vezérlésécel, c) alkalmazhatók permetezéshez is, illetve az evapo-transziprációs index meghatározásával a termésbecslésben is, az öntözésben és a szénmegkötés értékelésére, de a változó számú vetéshez is. A gazdák folyamatosan térnek át a traktor szenzortechnológiáról a dróntechnológiára.

Results (in English)

In the Nutri2Cycle project, two NDVI (normalized difference vegetation index) based precision farming technologies were tested, as the tractor-mounted sensor technologies, e.g. Yara and Green Seeker and the promising drone technologies (Unmanned Aerial Vehicles, UAV). The remote sensing in contrast to previous spot sampling, obtain more precise information about soil health and the vegetation status especially on the supply of nutrients and water. The advantage of using the tractor sensors is the 30-80 kg/ha/year reduction of the chemical fertilizers and after 2-4 year of application a more balanced nutrient supply to crops. Using drones have the advantage of having real time data from the plot and more precise maps, it can be used for different crops e.g. orchards, vineyards, furthermore is a tractor fuel economy and soil compaction avoidance. On the market several software is available and is easy to handle by the farmer after a short training. The farmers tend to use the drone technology.

Results (native language)

A Nutri2Cycle projekt keretében a precíziós gazdálkodás területéről két olyan NDVI (normalised difference vegetation index) alapú technológia került tesztelésre, mint a traktorra szerelt szenzortechnológiák pl. Yara és Green Seeker, a másik a nagy perspektívákat mutató dróntechnológia (Unmaned Aerial Vehicles, UAV), amelyek a korábbi pontszerű mintavételezésekkel szemben távérzékelésen alapuló eljárások által szereznek információt a talaj és a rajta levő növényzet egészségi állapotáról, különösen a tápanyag és víz ellátottságról. A traktor szenzor eljárás előnye, hogy évente 30-80 kg/ha műtrágya takarítható meg, illetve 2-4 év alkalmazás után látható a talajok egyenletesebb tápanyag ellátottsága. A drónhasználat előnye, hogy valós idejű információt és pontosabb térképet kapunk a tábláról, sikeresen alkalmazható gyümölcsösökben és szőlőültetvényknél is, kevesebb a talajtaposás így üzemanyag takarékos eljárás, az adatok feldolgozásához számos szotware áll rendelkezésre, egy rövid képzés után a gazdák könnyen kezelik a drónt. Ezért a gazdák szívesebben alkalmazzák a dróntechnológiát.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

ANNEX 1. Practice abstracts grouped according to Nutri2Cycle research lines

Research Line 1: Innovative solutions for optimized nutrient & GHG in animal husbandry		
PA title	**Status**	**Target audience**
RL1 - PA 4: Innovative solutions for optimized nutrient & GHG in animal husbandry	Published	All stakeholders
RL1 – PA 28 Farm scale anaerobic digestion of agro-residues to increase local nutrient cycling & improve nutrient use efficiency	Submitted	Arable land farmers, advisors, researchers, policy makers
RL1 - PA 16 Poultry and chicken manure management - practical considerations in Polish conditions	Submitted	Poultry farmers, researchers
RL1 - PA 26 Energy recovery from poultry manure	Submitted	Poultry farmers, researchers
Research Line 2: Innovative soil, fertilisation & crop management systems & practices for enhanced N, P efficiency and increased soil OC content		
PA title	**Status**	**Target audience**
RL2 - PA 3: Solutions for more nutrient efficient plant production as investigated by the H2020-NUTRI2CYCLE project	Published	All stakeholders
RL2 - PA 5: Enhanced recycling of (organic) carbon within European agricultural systems	Published	All stakeholders
RL2 – PA 18 : Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil	Published	Arable farmers, policy makers
RL2 – PA 31: Using digestate, precision agriculture and no-tillage to increase soil quality and organic matter stocking in soil	Submitted	Arable farmers, policy makers
RL2 – PA 44: Emissions from plasma treated sludge	Submitted	Farmers, advisors
Research Line 3: Tools, techniques & systems for higher-precision fertilization		
PA title	**Status**	**Target audience**
RL2 – PA 27: Using soil electrical conductivity and NDVI to idenitify distinct fertilizing areas in a vineyard	Published	Arable farmers, researchers
RL3 – PA 45: Application of BioBased Fertilizer on potato in sandy soil	Submitted	Farmers, advisors, policy makers
RL3 – PA 46 : Precision Application of manure in potato	Submitted	Farmers, advisors, policy makers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

RL3 – PA 49 Using precision technologies in plants nutrient management	Submitted	Arable farmers, researchers
RL3 - PA 22 Precision farming and optimised application: under-root application of liquid manure for maize and other row crops	Submitted	Poultry farmers, researchers

Research Line 4: Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		
PA title	**Status**	**Target audience**
RL4 - PA 2: Substituting primary resources by biobased products for a more sustainable European agriculture	Published	All stakeholders
RL 4 – PA 6: Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment	Published	Arable land farmers, advisors, researchers, policy makers
RL4 – PA 9: A study case on the use of digestate as bio fertilizer: characterization and environmental assessment	Published	Biogas operators, arable land farmers, researchers, policy makers
RL4 – PA 17: Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment – 2nd year	Published	Animal husbandry, pig farmers, researchers
RL4 – PA 7: Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers	Published	Animal Husbandry, (pig) farmers, researchers
RL4 – PA 8: Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency	Published	Animal Husbandry, (pig) farmers, researchers
RL4 – PA 10 : Closing the loops at farm scale : using livestock manure to fertilize feeding crops on agroforestry plots	Published	Farmers in general yet with interest toward mixed farming systems in particular
RL4 – PA 11 : Substituting mineral inputs with organic inputs in organic viticulture	Published	Viticulture farmers
RL4 – PA 12: Partial substitution of mineral fertilizers by animal manures in an apple orchard	Published	Animal husbandry, farmers
RL4 – PA 13: Enhanced manure recycling by producing manure-based fertilizers	Published	Animal husbandry, arable farmers
RL4 - PA 14 Use of digestate in orchards	Submitted	Arable farmers
RL4 – PA 19 : Producing bio-fertilisers from pig manure through different separations stages	Published	Animal husbandry farmers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

RL4 – PA 21 Refining bio-based fertiliser has limited effect on potato yield	Published	Animal husbandry farmers, advisors
RL4 – PA 23: Upcycling of food grade animal bone by-products for recovery and reuse of concentrated BioPhosphate products with BIO-NPK-C formulations	Published	Fertiliser companies, arable farmers, policy makers
RL4 - PA 24 Poultry manure derived biochar as a sorbent for removal of various contaminants	Submitted	Poultry farmers, researchers
RL4 - PA 25 Fertilizing products from poultry manure	Submitted	Poultry farmers, arable farmers,
RL4 – PA 29 : Short term N-effect of recycling-derived fertilisers focusing on crop yield and N losses to the environment	Submitted	Arable land farmers, advisors, researchers, policy makers
RL4 – PA 32: Producing bio-fertilisers from pig manure through different separations stages	Submitted	Pig farmers, arable farmers
RL4 – PA 39: Use of poultry manure compost and pig slurry to replace mineral fertilizers used as basal fertilization in maize crop	Submitted	Poultry farmers, arable farmers
RL4 – PA 40 : Ammonia recovery from raw pig slurry in a vacuum evaporation field pilot plant	Submitted	Pig farmers, researchers
RL4 – PA 41: 3R upcycling process for BIO-NPK-C compound biofertilizers to create user benefits	Submitted	Fertiliser companies, arable farmers, policy makers
RL4 – PA 43: Findings from bio-based fertiliser trial within an Irish cropland setting	Submitted	Arable farmers
RL4 – PA 47: Substituting mineral inputs with organic inputs in organic viticulture	Submitted	Viticulture farmers
RL4 – PA 48: Circular economy and fertilization: recycling of livestock effluents on agro-forestry plot.	Submitted	Farmers in general yet with interest toward mixed farming systems in particular
Research Line 5: Novel animal feeds produced from agro-residues		
PA title	**Status**	**Target audience**
RL5 - PA 1: Reducing EU's dependence on protein import (e.g. soy bean) by local production of novel animal feeds from agro-residues	Published	Policy makers, farmers, feed industry
RL5 – PA 15: Lemna minor cultivation for treating swine manure and providing micronutrients for animal feed	Published	Animal husbandry, pig farmers, feed industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.

RL5 – PA 30 : Why we should dive into potassium when growing duckweed	Submitted	Farmers
RL5 – PA 42: Microalgae cultivation in digestate for sustainable and local protein production	Submitted	Farmers, feed industry
Broader systemic assessment of nutrient recovery and recycling		
PA title	**Status**	**Target audience**
PA 20: Are consumers willing to pay a premium price for sustainable food?	Published	All stakeholders
PA 33: Environmental and social life cycle assessments of nutrient recovery technologies in agriculture	Submitted	Farmers, policy makers
PA 34: Life cycle assessment of black soldier fly rearing on agricultural residues	Submitted	Farmers, policy makers
PA 35: Life cycle assessment of constructed wetlands and duckweed ponds for treating liquid manure	Submitted	Farmers, policy makers
PA 36: Life cycle assessment of pig slurry acidification under Danish natural and regulatory conditions	Submitted	Farmers, policy makers
PA 37: Life cycle assessment of pig slurry acidification under Dutch natural and regulatory conditions	Submitted	Farmers, policy makers
PA 38 : Life cycle assessment of pig slurry acidification under Spanish natural and regulatory conditions	Submitted	Farmers, policy makers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773682.