EIP-AGRI Focus Group - Nutrient recycling

Mini-paper – *On Farm Practices*

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1. Introduction

There is a long tradition of using manure as fertiliser on farms. Even today, most of the phosphorus used as fertiliser in the EU comes from manure, as does a substantial proportion of the nitrogen (Buckwell and Nadau, 2016). There are also possible new sources for recycled nutrients, (Table 1).

Table 1. EU nitrogen and phosphorus recycling potential, total amounts and average amounts per year on agricultural land in the EU if spread evenly. For comparison, the mineral fertilizer amounts. [1]

	N total Mt/y	N average kg/ha/y	P total Mt/y	P average kg/ha/y
Manure	7 - 9	40 - 51	1,8	10,2
Biowaste	0,5 - 0,7	2,8 - 4	0,1	0,6
Slaughterhouse waste	?	?	0,3	1,7
Sewage	2,3 - 3,1	13 - 18	0,3	1,7
Mineral fertilisers	10,9	62,0	1,4	8,0

[1] A. Buckwell & E. Nadau (2016). Nutrient recovery and Reuse (NRR) in European Agriculture. The Rise Foundation.

The reason for using fertilisers is to fill the nutrient need of the plants cultivated. Thus from the agronomic point of view, essential factors in bio-fertilisers are their nutrient content and ratio and nutrient release rate and not the origin of the nutrient or recycled nutrient. Classification of organic fertilisers is useful for legislation and markets, but for a farmer a more useful way of classification deals with fertilising value and other features that affect the use of the product, i.e. the logistics and machinery needed.

Both with manure and many organic fertilisers, the challenge of use is the nutrient ratio, mostly ratio of N and P, which does not meet the needs of the plants. Also the nutrient availability or nutrient release in relation to plant nutrient uptake is a challenge. Still, it is possible to efficiently replace mineral fertilisers by using organic fertilisers, and furthermore, to efficiently use mineral fertilisers when needed to fill the total nutrient needs of the plants. In fact, this is already widely being done on the animal farms: using manure or slurry, and topping up with mineral fertiliser.

If use of both organic and inorganic fertilisers, efficient nutrient use is necessary to prevent losses into air and/or groundwater. The aim of this paper is to give a look on different aspects affecting the nutrient use in practice, and what possible gaps there might be, in either on farm practice, or related research or advisory materials.

Thus, this Mini-Paper deals with the following topics:
- different types of fertilisers from the farmers' point of view
- some characteristics of organic fertilisers and their use
- optimal use of organic fertilisers
- good practices, examples and experiences using organic fertilisers, together with inorganic fertilisers when needed
- on-going and finished project on the theme
- knowledge gaps – need for projects, research, knowledge dissemination, operational groups

2. Different fertilisers – different uses

1. Organic fertiliser types from farmers' point of view

From the farmers' point of view, the most practical way of classifying the organic fertilisers is by their features. This kind of classification could include at least the following:
- nutrient content (high – medium - low: total-N, soluble-N, total P, soluble P, N/P ratio, C/N ratio)
- nutrient release rate (fast – slow)
- organic matter content (high – low)
- solid (loose, granulate) – liquid

Different types of organic fertilisers, as grouped according to treatment, DM-content and nutrient concentration/release characteristics:
- liquid animal manure
- biogas slurry
- liquid fraction of separated slurry
- solid animal manure
- solid fraction of separated slurry
- compost, loose
- granulates of compost, solid manure or solid fraction of separated manure

- miscellaneous fertilisers of farm-origin: ammonium-sulphate and other liquid fertilisers
- struvite
- liquid fraction from nitrification-denitrification process

- tailor made or blended fertilisers

For a farmer, the source is of importance, where there is concern for possible harmful substances, like the concentration of heavy metals or organic pollutants or hygienic parameters. For example, some buyers of agricultural products have forbidden the use of sewage sludge, and it is also forbidden in organic farming.

2. Plant needs, nutrient availability

Very important information for farmers is also classification of plant types by nutrient need and nutrient uptake rate. This will help farmers to choose the right type of organic fertiliser for the right type of plant.

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An example of a very practical guide towards optimal use of organic fertilisers according organic fertiliser and plant type is f.e. in the German fertiliser regulation. In the table below is a calendar for nutrient use efficiency of biogas slurry for different plants.

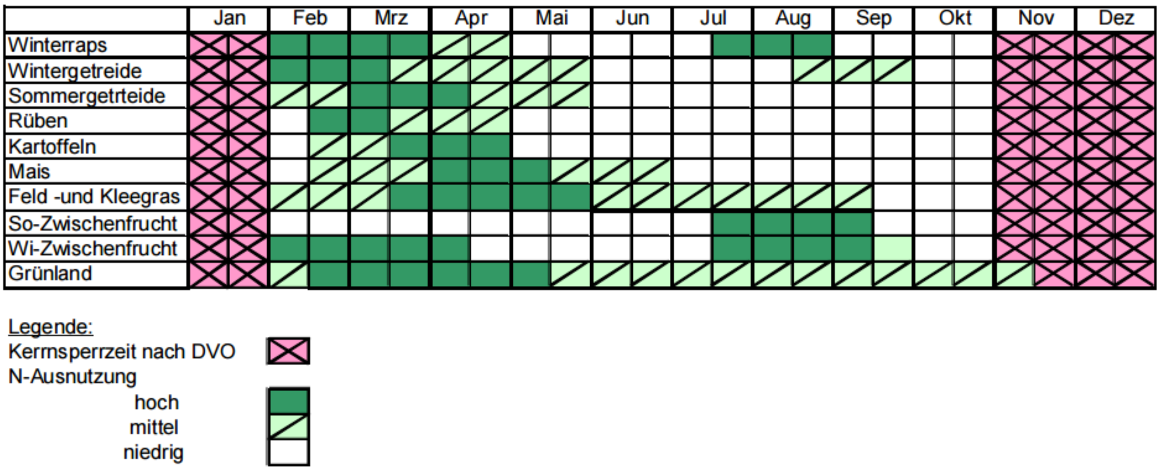

Abbildung 29: Ausbringungskalender für Biogasgülle und Gärreste unter Berücksichtigung der Düngeverordnung 2007

As a basic rule, slow release composts act best as soil conditioner, with a broader time span for application and nutrient uptake accepted. For products with an immediately availbale nitrogen fraction, application should only take place during the period of plant vegetation period, when there is a plant need for quickly available nitrogen.

3. Some characteristics of organic fertilisers and their use

1. Differences in farm types

Different types of farms are in a very different position in the use of organic fertilisers. Animal farms are often regarded as one group, but in reality there are big differences in nutrient contents in manures from different animals and also the typical plants cultivated in the fields. When optimizing the use of manure (and organic fertilizers) on animal farms, the following should be taken into consideration:

- differences and specialities according to animal type, typical plants grown on a special farm type, typical features of manure
  - milk production: grass (+ maize/grain), mostly liquid manure
  - beef production: grass (+ maize/grain) both liquid and solid manure
  - pig production: grain (barley, wheat, oats), mostly liquid manure
  - poultry and egg production grain (wheat, barley), mostly solid manure
- differences in soil nutrient content, following the long term use of the specific manure type

Optimizing the use of manure and organic fertilisers on crop farms

- differences and typicalities according to different crops, their nutrient need, nutrient uptake rate, proper "time-windows" for fertiliser application
- grain (wheat, barley, oats, rye, triticale) (winter and summer varieties), oilseed, mais, sugarbeet, potatoe, grass, horticulture, viticulture, forestry)

For the different farm types, optimal strategies of using manure and organic fertilisers (as the only fertiliser or together with inorganic fertilisers) should be widely recognised and used.

2. Excess, balance or deficit of nutrients in the area

- areas with excess of nutrients, mostly manure, may also be e.g. biogas slurry (example?) or ammonium-sulphate from animal house air-cleaning (Flanders)
- areas with deficit of nutrients (certain areas in France, several of the EU-13 countries)
- differences in farm-level, regional level and country level nutrient balances

These differences affect strongly the markets of manure and organic fertilisers, the price can be positive or negative, depending on the amount of manure or other organic fertilisers offered in a certain market.

3. Logistics – storage, transport, application

- special storage capacity may be needed (liquid fertilisers, slurry, biogas slurry)
- special machinery may be needed: application using the existing machinery for mineral fertiliser possible only for granulated solid organic fertilisers, otherwise special machinery is needed (slurry tanker, slurry injector, trailing hose, manure spreader for dry manures and composts)
- use of contractors and implications for timing of the chain of different tasks on the farm)
- special measures needed with the use of organic fertilisers, f.e. incorporation of slurry and biogas slurry after spreading
- see Mini-Paper Logistics and cooperation
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4. Processing and other special technologies

- better nutrient ratio (f.e. separation)
- better nutrient availability (biogas process)
- possibility to transport excess nutrients (f.e. separation)
- better hygienity (f.e. composting)
- better hygienity, transportability, logistics (composting, drying and granulating of dry organic fertiliser
- see Mini-Paper State of the art of technology and Mini-Paper Logistics and cooperation

5. Using both organic and inorganic fertilisers – finding the optimal combinations

1. Examples of good on farm practice in finding optimal combinations

Case Flanders 1:

Use of ammoniumsulphate + pig slurry in fertilising potatoes and grass: upgrading pid slurry with N from ammoniumsulphate, to achieve the optimum level of N and P

Case Flanders 2:

Separation of manure (dairy/pig) results into a N-rich/P-low liquid fraction and a C-rich/P-rich solid fraction; in this way the N/P ratio is adjusted. The degree of separation of nutrients depends on the separation technique in use. In regions where organic fertilising potential surpasses plant needs, separation can be a used to obtaining a liquid fraction with a better N/P ratio, according to the fertilisation limits and the plant needs. By separation, the liquid fraction is more homogenised (than the raw manure) and can easily be injected on i.e. grass land. The solid fraction, which contains a high amount of carbon (and P), can be used on arable land (i.e. maize) as soil improver or can be exported from the farm. According to the fertilisation limits, by on-farm separation, the animal farmer can use more manure (expressed in volume) on its own land instead of using raw manure. In regions with a high manure surplus (f.e. Flanders) there is a lot of interest in this technique (especially by dairy farmers who also have their own land). The separation system can be an own investment or a mobile system (shared by different farmers or property of contract worker)

Case Denmark:

A special technology to minimise the ammonia emissions in animal housing, slurry storing and slurry spreading is the use of different slurry acidification techniques (SAT). Acidifying the slurry also results in more nitrogen left in the slurry and thus higher nutrient value of the slurry to the plants. Acidification is usually made using sulphuric acid. When applied on the field, sulphur also acts as plant nutrient. There is an ongoing Interreg-project testing the use of SAT technologies in eight countries around the Baltic Sea **http://balticslurry.eu/. The technology is now being used only in Denmark, where approximately 20% of all slurry is treated using SAT.**

Case Finland:

Use of pig and cow slurry + mineral N in fertilising wheat, using the nitrogen-sensor –technology in applying the mineral N: A farmers co-operative Lapinjärven farmarit, with three member farms, one pig farm, one milking cow farm, one crop farm. On all three farm, first slurry is applied on the crops, then a couple of weeks later mineral N fertiliser is being applied using a Yara N-sensor. According to the experiences of the farmers, the N-content of the slurry varies between years, slurry storages and even spreaded slurry tanks, so there are variations in the amount of N spread in the slurry in different parts of the field. The slurry nitrogen release rate and plant availability also varies, depending on soil moisture and temperature. By the use of the N-sensor, the amount of added mineral N fertiliser is adjusted spatially precisely according to the N release of slurry and plant need.

2. Examples of farm scale and regional co-operation in nutrient recycling

Examples of farm scale level co-operation models: animal farms and crop farms

- several examples are in the Nordic countries as Finalnd, Sweden, Denmark where is a strong tradition of cooperation between farmers and several co-operatives exist. Such manure processing co-operative (owned by farmers) e.g. is in Finland the Biovakka Suomi Oy **www.biovakka.fi.**
- In France theTRAME ACF: farmers organisation for organic waste (**http://www.composteursdefrance.com** /), cooperatives in livestock areas (Triskalia) or cooperatives manure processing (Omnisolis) **http://www.omnisolis.com/methanisation.php**,
- In The Netherlands BMC Moerdijk a biomass power plant using dried poultry manure as the main fuel source (**www.bmcmoerdijk.nl**), collected from a large number of poultry farms in the NL, KUMAC is a manure processing factory owned by DEMAC Pig Producers cooperative and Kuunders Agricultural contracting **www.kumac.nl**)
- In Flanders, the cooperative 'LIMCOMEST' is recently created where animal farmers (12) from the northern part of the province of Limburg (surplus of manure) work together with arable farmers (7) in the southern part of the Province (low supply of manure). The objective is to have a better consistency between demand and supply of raw manure, by having a organised transport between two regions. A collection point will be foreseen where manure from the

different animal farmers is collected and mixed in order to supply a uniform content to the arable farmers.

Examples of regional level co-operation models:

- studies made in the INEMAD (**www.inemad.eu**) project revealed that there is a possibility to cooperate between regions with nutrient surplus and nutrient scarcity (mostly between Western European countries with a high animal density). This case of cooperation is missing in the Central and East European countries with low animal density. For the high animal density countries there is a pressure to act mainly due to nitrate and water directive, as well as commitments and regional legislations resulting from these directives. For example in The Netherlands the manure surplus leads to high disposal costs. The main aim is to transport (export) nutrients out of the regions. On the other hand there are regions with a need of fertilizer (France).

  The main environmental pressures mentioned by stakeholders are the high nitrogen contents in soils and water in some areas , the phosphor saturation in the soils, problems to reach the goals of the EU Water Framework Directive, and spreading calendar and need to stock digestate in autumn and winter and odours problems are increasing in summer with organic fertilizers spreading. The renewable energy support mechanisms in the countries leads to the establishment of cooperations in the field of biogas plants. Further reasons for cooperation are the deficit of input material for anaerobic digestion, the legal barriers to increase farm size, increasing value of nutrients and the assurance of delivery of a good quality product.

Examples of manure markets and contracting

- case Svens Foder and EcoNatur, **http://www.ekonatur.se/**, Sweden = ??

6. Examples of projects

Short description can be listed here or they can be provided in the specific chapters ☞ More elaborated proposal to be put in the **web form**

- In the recently closed (2012-2016) INEMAD (**www.inemad.eu**) project a report was performed on farmers willingness to cooperate in nutrient exchange. The aim is to understand how interactions between firms should be organized to improve nutrient use efficiency in the different countries. The interactions potentially can be implemented between crop and livestock farms, between different types of livestock farms, between livestock, crop and processing firms or between processing firms (e.g. biogas plants). The objectives was: to assess the success factors of collaborations between firms for nutrient exchange , to optimize the logistics of biomass flows by advice on transport, prices of biomass and the suitable locations of of processing plants, to optimize the exchange of nutrient rich products and to present the obstacles and the corresponding ways to eliminate them. Besides the exchange of organic fertilisers also the exchange of crops (energy, market or feed) and animals are indirect forms of trading nutrients. The existing strategies were divided into five sectors as exchange of products/energy, exchange of knowledge, joint purchase (capital)/sale exchange of labour and exchange of land. The cases of the participating countries are presented.

7. Gaps in knowledge, need for farm level practices dissemination

The regional and farm level situation in the use of organic fertiliser varies a lot, depending e.g. the farm type and the type of organic fertilisers easily available on the region. There are a lot of new technologies available to more accurate fertilisation with manure and other organic fertilisers, but they might not be widely used among the farmers yet.

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There may be some practical obstacles in the optimum usage of organic fertilisers and manure on the farms, e.g. lack of knowledge, lack of storage capacity, lack of economic incentive. There are in all cases possibilities to develop the processes to the better. Here, of great importance would be

- farmer-to-farmer knowledge dissemination
- farm advisory – group advisory systems – nutrient use efficiency and knowledge benchmarking
- intelligent incentives to help adopt new technologies and farm level tools

8. Examples of projects

Examples of ongoing/finished farm advisory project dealing with NUE and organic fertilisers

A very good example is the Swedish Greppa Näringen -project, with a lot of materials and farm visits, with special emphasis on nutrient use efficiency on different farm types
http://www.greppa.nu/om-greppa/om-projektet/in-english.html

9. Proposal for potential operational groups

- farmer-to-farmer knowledge dissemination
- farm advisory – group advisory systems – nutrient use efficiency and knowledge benchmarking, including knowledge dissemination between farmers/advisory groups from different EU-countries
- local/small scale trials on intelligent incentives to help adopt new technologies and farm level tools
- Operational groups which link farmers with advisory services and researchers to put in place use of research proven best available technologies to improve nutrient recovery from bio-based fertilisers including animal slurries on farm. For example there is a large range in the adoption of technologies to cut N loss from slurries as ammonia gas. Some countries having almost 100% adoption of low emission spreading and some countries having very low adoption. It is proposed that operational groups to promote low emission spreading should be established in countries with low uptake.
- Implementation of the use of liquid fraction of separated slurry as organic NPK-fertiliser on the farm. Separation results in a better NPK ratio, which can stimulate the use of organic fertilisers, with better characteristics, according to the plant needs. In the operational group, demonstration and knowledge exchange is needed in order to make farmers familiar with this new product. Also better matching of demand and supply needs to be accomplished (animal farms and crop farms).

10. Proposals for (research) needs from practice

- Knowledge on real farm level practices compared to best available systems
- Research or collection of research based knowledge on different type (agronomic use) of organic fertilisers and their use on different plant types – a synthesis of suggested good farm level practices
- Research quantify the increase in mineral fertiliser replacement value possible for bio-based fertilisers by adoption of best management practices on a country or system specific basis.
- A special need of knowledge: using separated digestate in closed horticultural systems