Focus Group Fertiliser efficiency in horticulture

Mini-paper - Opportunities and bottlenecks in the utilisation of new kinds of organic fertilisers

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Introduction

Organic fertilisers applied in agriculture may originate from very different sources. They can be produced on-farm, as farmyard manure, slurries, poultry manures, digestate or can originate off-farm (mostly from food industry residues). (see the annex for some of the available organic fertilisers). These materials are composed of valuable nutrient (fertilizing value) and organic matter (source of organic carbon) which can benefit the majority of crops, including horticultural ones. Their use has an important impact on all components of soil fertility (chemical, physical and biological) and on the environment (in terms of risk of both water and air pollution). Indeed, the increased nitrogen application rates that have been registered in horticultural productions have increased the level of NO3- leaching and soil N_2O release in the atmosphere and it is considered that agriculture contributes up to 90% of the total N_2O anthropogenic greenhouse gas (GHG) emissions. It should be mentioned that in different European regions there is a large diversity of sources (link with livestock densities) in some regions are surpluses (e.g. The Netherlands, Flanders with high livestock densities), in others is a lack of sources (e.g. Slovenia, Hungary with low livestock densities). This results in different opportunities and bottlenecks for these regions.

Solid and liquid organic fertilisers are generally slow-release fertilisers and rely on biological activity for mineralisation into forms that can be absorbed by the plants. They are used mainly as base dressing but the top dressing is also possible (less for leafy vegetables). For top dressing concerns are raised for the vegetables hygiene and food safety (there are differences in legislation between the EU countries). Besides the influence of soil microorganisms, the process of mineralisation depends on several environmental conditions (e.g. soil temperature and humidity) and agricultural practices (e.g. tillage stimulates mineralisation). Therefore, only a portion of the applied nitrogen may be available to the crop in the season of the application. To compensate for this, the producer could consider applying liquid mineral fertilisers, particularly for short-season crops. Indeed, the lack of temporal synchrony between the mineralisation of N from organic matter and its uptake by the crop is a major challenge for fertility management with organic fertilisers.

As both chemical and organic fertilisers have their own advantages and disadvantages, the establishment of a complex nutrient management system is preferred for horticultural crops, although cropping systems without chemical fertilisers are also a normal practice (i.e. organic farming). The production system is characterised by a reduced input of chemical fertilisers (e.g. to reduce the energy needs and GHG emission of the sector) in combination with application of organic fertilisers such as animal and green manures, composts of different origin (e.g. from digestates), other organic products (e.g. food industry by-products). Another complementary practice is the use of microorganism's inoculum, based on mycorrhizal fungi and plant growth promoter bacteria.

Research results demonstrated the beneficial effect of combined use of chemical and organic fertilisers on the nutrient use efficiency and on soil fertility. In this paper we aim to underline the opportunities and limitations, mainly for the new kinds of organic fertilisers, which should be considered by the different stakeholders (i.e. farmers, advisors, policy makers) when dealing with such products.

Opportunities and bottlenecks for new organic fertilisers

Opportunities

The use of organic fertilisers (manure and other organic sources) could open an array of opportunities/benefits related to the agronomic, economic and social domains as:

a) agronomic benefits:

- enhancing soil biological activity by favouring the root colonisation by mycorrhizal fungi or by rhizosphere bacteria: these microorganisms can improve N, P and K supply (and of microelements) by mobilisation of low-soluble nutrient,
- improving the soil physical properties, thus ameliorating soil structure and water holding capacity,
- supplying nutrients in a balanced way, which increases plant growth and prolongs the plant health status by suppressing certain soil borne diseases and parasites,
- the new organic sourced and processed fertilizers (often marketable products) make it possible to be applied according to the nutrient demand of the plant and soil status. This opportunity is mainly relevant to regions with a high soil P content, where P has become the limiting factor of fertilisation by organic fertilisers.
- environmental benefits due to keeping/enhancing microbial diversity, reducing soil acidification or alkalisation and by reduction of GHG emissions or decomposition of toxic substances (e.g. the carbon footprint of the NH_4NO_3 mineral fertilizers production is 3,6 kg CO_2e/ kg N, the transport 0,1 kg CO_2e/kg N and the fertilizer application (direct and indirect emission) 5,6 kg CO_2e/kg N) (source: Yara, 2010)

b) economic benefits:

- reduced needs in chemical fertilisers, soil management practices,
- reduced costs of externalities (i.e. those linked to the whole production and utilisation chains),

c) social benefits:

- enhanced recycling of organic materials, with benefit for the environment and for the development of new industries/production processes,
- facilitating the contact between local farms for exchange of organic sources which should allow to choose a product that is the most efficient for a particular crop.

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Bottlenecks

Some bottlenecks that can limit the wide use of new organic fertilisers can be pointed out:

- lack of proper common (EU) legislation that define their characteristics, quality standards, marketing requirements and safety use,
- legislation constrains at different levels (EU, national, regional) in the use of locally available products (particularly of animal origin) that need to undergo a slight transformation process. There is not always a very clear legislation about the use of these products,
- limited knowledge on sustainability of the products in terms of energy consumption, overall GHG emission, crop applicability,
- lack of knowledge on the availability and on the characteristics (e.g. quality according to the source linked with quality assurance and certification) of the new organic fertilisers, for example what is the fertilizer replacement value. There are a few certification schemes in European countries and regions, but in many cases they are not compatible (e.g. VLACO in Flanders and RAL in Germany). This is an obstacle in trading,
- lack of knowledge at farmers level about the effectiveness of the new organic fertilisers, which reduces their potential application,
- lack of monitoring the manure stocks and trade (exchanges). The monitoring/registration system is different in the EU regions, there are sources of organic fertilizers which are not monitored (e.g. chicken manure in Hungary). There is also a differentiated monitoring by central authorities (e.g. registration only in the nitrate vulnerable zones) and statistical offices (national registration).

Some particularities for new organic fertilisers are:

- they are comparatively low in nutrient content, so a larger volume is needed to provide enough nutrients for crop growth,
- the nutrient release rate is rather slow to meet crop requirements in a short time, therefore nutrient deficiency may occur for some specific crop types,
- the major plant nutrients may not exist in organic fertiliser in sufficient quantity to sustain maximum crop growth. For example manure can be processed in order to have a better nutrient ratio or a combination of products can used,
- for some organic products as the compost and digestate the nutrients are highly variable, compared with chemical fertilisers the composition is input dependent,
- in cases when the organic sourced fertilizers has to transported to large distances (the optimum is below 5-7 km) and there are large amounts used/hectare, the total cost (transportation and fertilizer cost) can be higher compared to the chemical fertilisers.

Further research needs/ knowledge gaps

- which organic sourced fertilisers are the most widely used and suitable for horticultural crop production? why?
- what are the specific aspects in regions with organic fertiliser shortage and regions with excess?
- is the organic fertiliser trade/exchange monitored? what is the farmers behaviour in using these fertilisers?

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- in case of marketable organic products how sustainable is the product in terms of energy consumption, GHG emission, financial costs and fertiliser efficiency and which product or combination of products are suitable for different EU regions?
- what is the N-P-K and micronutrients substitution value of different organic sourced fertilisers?
- which products to be considered as organic sourced fertilisers and what are the required qualities (physical, chemical, biological parameters)? is there a need for certification?

Examples

1. Case Poland

Fields trials carried out in Poland on strawberry, other small fruits, several vegetables (e.g. tomato, cabbage, salads) and apple maiden trees (in nursery) showed that application of both soil and foliar organic fertilisers of different origins was sufficient to boost growth of plants and yield of fruits and maiden trees. The products tested included dried animal manure, vermicompost extract, composts based on lignite and food industry wastes inoculated with white rot fungi (Shiitake and Pleurotus), seaweeds extracts, a by-product of bakery yeast production and plant extracts. In all cases, a lower input of N (from 50% up to 70%) in comparison to standard chemical fertilisation was associated with an increased soil microbiological fertility (increased number of beneficial bacteria and nematodes, reduction of plant parasitic nematodes), higher colonisation of plant roots by mycorrhizal fungi. Plant growth and yield were at least equal to the chemical fertilised (Grzyb *et al*. 2012, 2013; Malusà *et al*. 2012; Stępien *et al*. 2012).

2. Case Belgium

Eight fertilisation strategies were compared in a field trial on Alfisol in Belgium (humid temperate climate): cattle slurry (CSL), farmyard manure (FYM), vegetable, fruit and garden waste compost (VFG), high C/N farm compost (FCP1), low C/N farm compost (FCP2), exclusively mineral fertiliser (MIN N), no fertilisation (NF+), no fertilisation and no crop (NF-). After five growing seasons, VFG resulted in the highest soil organic C (1.46% SOC) and total N (TN) contents (0.117% TN). Soil organic carbon (SOC) and TN contents of the MIN N plots, on the other hand, remained unchanged and were even similar to those of NF+ plots, despite greater biomass production on the MIN N plots than on the NF+ plots. Application of organic matter mostly increased dehydrogenase, glycosidase and glucosaminidase activity, but only FYM raised the activity of all three enzymes significantly compared to MIN N. Of the five organic amendments tested, only VFG suppressed Rhizoctonia solani (65% suppressiveness). Plots treated with FCP1, on the other hand, were highly conducive to R. solani (28.3% suppressiveness). Suppressiveness against R. solani probably depended on the maturity and cellulose content of the organic amendments. Highest microbial biomass C contents were found in the VFG plots. Finally, a soil quality index was developed using stepwise canonical discriminant analysis. The glucosaminidase and glycosidase activity and TN content were the most important parameters of the index. According to this index, FYM resulted in a significantly higher soil quality than the other treatments. Moeskops *et al*. (2012) conclude that farmyard manure seems to be the preferred organic amendment for maintaining soil quality in arable fields under temperate climatic conditions.

In another field trial experiments in Belgium the nutrient balances were assessed and the physico-chemical soil fertility and quality were evaluated. The biogas yield of the harvested energy crops was determined. An economic and environmental evaluation was conducted. Application of bio-digestion waste derivatives induced small, albeit statistically insignificant improvement in crop yield, soil fertility and quality compared to current common practices using animal manure and synthetic fertilisers. Moreover, the use of these products might stimulate nutrient mobilisation from the soil, thereby increasing the use efficiency of soil minerals. Vaneeckhaute *et al.* (2013) conclude that for all scenarios the calculated economic and environmental benefits were significantly higher than the reference. It is clear that the reuse of bio-based products as nutrient supply in agriculture should be stimulated in European legislation Further field research is on-going in order to validate the results and evaluate the impact on soil quality in the longer term.

Conclusions

From the brief analysis of the possibilities and constraints in using the new organic fertiliser sources we could conclude that there are at least three main areas which should be developed in order to foster the use of this kind of fertilisers referring to:

1) the agronomic evaluation of the new products and the building of knowledge by farmers and advisors about the benefits for plant production,
2) the assessment of their economic and environmental benefits,
3) the definition of an uniform legal framework which would regulate the production processes of these fertilisers, their marketing quality standards and the application possibilities.

To the first area we can include the development of Good Agricultural Practices and integrated crop production requirements which foresee/promote the use of the new organic fertilisers fulfilling the legal requirements derived from environment protection (e.g. managing nitrate losses, particularly in Nitrate Vulnerable Zones). It is necessary to have field demonstrations for agricultural and horticultural crops and developed guidelines for farmers in using this fertilizers. The guideline should stress the common/alternative use of the chemical fertilizers with organic sourced fertilisers and give guidance on the applicability of the available products (processed and unprocessed), crops, quantities, time of application and machinery.

To the second we can include a viability evaluation process based on a life cycle analysis (LCA) for the different organic fertilizers. The third one- to address the legal framework -is necessary to stress the utilisation of the Good Agricultural Practice requirements in animal husbandry, the compliance with the EU supports to the recycling processes, improvement of the implementation of EU waste law by harmonising criteria used by Member States and provide new organic sourced fertilisers. A common quality assurance scheme and certification system has to be developed and applied for organic sourced fertilizers which include the list of allowed input material and the list of restricted input materials. In case marketable organic fertiliser products a labelling (in case of packed products) and certification system has to be in place. Doing so this will contribute to the biosafety of fertilisers. A specific aspect refers to fulfilment of the EU cross compliance criteria like those for investments in manure handling and agri-environmental schemes applications.

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Analysis of some new organic fertilisers in comparison to common animal manure

Fertiliser type	Costs	Labour demand	Knowledge gaps	Risk in crop production	Risk in crop quality	Legislation	Other issues or constraints (?)
farm yard manure	low	low	no	low, up to the applied quantity	no	specified by national rules (known)	applicable
slurries	low	low	no	low, up to the applied quantity	no	known	applicable with restrictions, environmental constrains
composts from agricultural sources	medium	low	no	low	no	known	applicable, certification
raw agricultural digestate	medium	low	up to the inputs	low, up to the applied quantity	no	known	applicable with restrictions, environmental constrains consider energy production, certification
separated agricultural digestate	medium	low	up to the inputs	low, up to the applied quantity	no	known	applicable with restrictions, environmental constrains, certification
products from agricultural digestate	high	low	medium- high	low	up to the processing method	gaps	applicable with certification
sewage sludge (including also raw digestate and separated digestate)	Low/medium	low	no	low, up to the applied quantity	up to the source	known	environmental constrains, energy production, not applicable in all EU countries

Fertiliser type	Costs	Labour demand	Knowledge gaps	Risk in crop production	Risk in crop quality	Legislation	Other issues or constraints (?)
compost from sewage sludge and other inputs	medium	low	no	low	up to the source	known	applicable with certification
products obtained from manure, digestate and from sewage sludges	high	medium demand	medium-high	low	up to the processing method	gaps	applicable with certification
vermicompost	medium	medium	no	low	no	known	applicable
food and feed industry residues non-processed and processed	medium	medium	up to the source	low, up to the applied quantity	up to the source	gaps	applicable after processing (biogas or composting), environmental constrains, certification
biochar from different sources	high	low	medium	low	no	gaps	applicable, consider the energy need, certification

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