IMPROVING INPUTS FOR ORGANIC FARMING

Project Title:	RELACS: Replacement of Contentious Inputs in organic farming Systems
Project number:	773431
Project Acronym:	RELACS
Proposal full title:	Replacement of Contentious Inputs in organic farming Systems
Type:	Research and innovation actions
Work program topics addressed:	SFS-08-2017 Organic inputs – contentious inputs in organic farming

Deliverable No 7.5: European roadmap for phasing-in new nutrient sources

Due date of deliverable:	28 February 2022 (M46)
Actual submission date:	07 April 2022 (M48)
Version:	v1
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This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 773431

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Project title	**RELACS: Replacement of Contentious Inputs in organic farming Systems**

Deliverable title	European roadmap for phasing-in new nutrient sources
Deliverable number	7.5
Deliverable version	V1.0
Contractual date of delivery	28.02.2022 (M46)
Actual date of delivery	07.04.2022 (M48)
Document status	Submitted
Document version	v2
Online access	
Diffusion	Public
Nature of deliverable	Report
Workpackage	WP7
Partner responsible	IFOAM EU
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Keywords	Organic farming, nutrients, conventional manure, recycled fertilisers, reduction pathway, policy support

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1. Executive summary

In organic farming, plants should primarily be fed through the soil ecosystem, therefore fertilisation focuses on feeding the soil life. Organic farmers rely on biological nitrogen fixation by legumes, complemented by recycling, regeneration and/or addition of organic materials and nutrients.

Among the external inputs used for organic plant nutrition, manures from non-organic farms and rock phosphates are considered the most problematic due to contaminants, the usage of non-renewable sources as well as the structural dependency on conventional farms. Reducing their use is challenging because on the one hand it could increase the risks of mining the soil – especially in stockless farms – and on the other hand, it would further reduce the productivity per area.

The RELACS project has contributed to open pathways to alternative sources of plant nutrition needed to reduce the dependency on contentious fertilizers and manures in plant production. To do so, RELACS has analysed opportunities for new technologies to recycle nutrients from waste streams for organic agriculture, focusing on three recycled inputs: struvite, anaerobic digestates and calcined sewage sludge ash.

The analysis of RELACS were presented to relevant stakeholders of the organic sector and to EU policymakers, in order to assess their acceptability of the recycled inputs and to identify under which conditions they could be adopted. This multi-actor approach and fact-based dialogue allowed to develop a "European roadmap for phasing in new nutrient sources in organic farming systems", with the aim to propose fair, reliable and implementable rules to achieve an identified realistic integration of new recycled inputs into organic nutrient supply strategies.

The RELACS project has shown that the importance of nutrient supply in organic farming has been underestimated so far. Current soil fertility management of organic farms may pose a risk either for soil fertility as indicated by negative balances, or for the environment due to high surpluses. In addition, the extent of 'dependence' on conventional sources may appear low at the aggregate level, but there are significant inter-regional variations, and some production systems remain highly dependent on external sources of N besides biological nitrogen fixation, such as stockless arable and low animal intensive farms.

Reducing the dependence of organic farms on conventional manure and external nutrients from non-renewable sources is nevertheless possible in the medium term, but it needs to be well prepared. This pathway relies on the development of recycling of societal waste streams, where recycled fertilisers can help to replace fertilisers from conventional origin to some extent. Increasing access to recycled waste products will require policy support in several fields. Further research is needed to ensure that the proposed recycled fertilisers are both yield efficient and environmentally safe (especially with regards to contaminants and microplastics). Significant financial and logistical support will be needed to improve waste collection systems. Regional approaches will be key to adapt the demand with local availability of nutrient sources. Farmers also need to be supported, through intensified advice on nutrient balances and incentives to use recycled fertilisers. In parallel, the organic sector will have to agree on the criteria for determining whether a recycled fertiliser is compatible with the principles of organic farming. The Organic Regulation will then have to evolve to reflect these developments.

While the Farm to Fork strategy sets a target of 25% organic farmland by 2030, it also contains a target to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This is supposed to lead to a reduction of the use of fertilisers by at least 20% by 2030. Given that considerable nutrient exports are unavoidable, organic farms will inevitably require a degree of import of nutrients for replacement. Future policy initiatives related to soil fertility management should reflect this point inherent in the functioning of all production systems, not just organic systems. Finally, it is important to emphasise that the challenge of soil fertility in organic farming (and beyond) is also strongly linked to farmers' choices about the level of land use efficiency, which is strongly influenced by market constraints and the policy framework.

2. Introduction

Organic agriculture works with living eco-systems and cycles, emulates them and helps sustain them, in order to create resilient agricultural systems. Ecological processes and recycling are at the heart of the organic approach to plant nutrition, allowing to minimise dependence on external inputs.

In organic farming, plants should primarily be fed through the soil ecosystem, therefore fertilisation focuses on feeding the soil life. Organic farmers rely on biological nitrogen fixation by legumes, complemented by recycling, regeneration and/or addition of organic materials and nutrients. Important soil fertility management practices are crop rotation design, crop residue management and the application of animal manures, composts and a variety of permitted commercial fertilizers and soil conditioners.

As established in the Organic Regulation (EU) 2018/848[1], external inputs authorised as fertilisers in organic production are limited to "natural or naturally-derived substances" and "low solubility mineral fertilisers". They are composed of material of microbial, plant or animal origin such as livestock manure or organic waste from the cities and food industry. The list of authorised products is established in Annex II of Regulation (EU) 2021/1165[2].

Some of the external fertilisers authorised in organic production come from conventional agricultural systems, such as manure, animal by-products (e.g. meat and bone meal, keratins or blood), or plant-based products, such as residues of the oil, sugar or plant starch industry. This dependence on conventional farming is problematic for the organic sector, as their supplier's environmental or animal welfare practices may not be in line with organic principles. Other nutrient sources authorised in organic farming are considered contentious because they come from non-renewable sources, such as rock phosphate. However, numbers of organic farms depend on external fertilisers to close nutrient cycles, especially those lacking livestock.

In parallel, organic agriculture has grown considerably in Europe over the past decades, and this trend is now strongly supported politically with the EU Green Deal and the Farm to Fork target of 25% organic farmland by 2030. Given the expected growth of the organic sector for the coming years, reducing the dependence on contentious nutrient sources will be challenging.

The RELACS project aimed at assessing alternative sources of plant nutrition needed to reduce the dependency on contentious fertilisers and manures in plant production, with a focus on recycled fertilisers.

This roadmap presents the steps to reach this goal.

3. Methods

RELACS is broken down into 6 research and development work packages (WPs1-6), in which scientists and farmers working closely together with industry partners have developed, explored and adapted innovative solutions and strategies to reduce the use of copper (WP1), mineral oil (WP2), contentious fertilisers and manures (WP3), anthelmintics (WP4), antibiotics (WP5) and synthetic vitamins (WP6); one work package dedicated to the science-practice dialogue to support the development of relevant EU policies (WP7); one for outreach and technology transfer (WP8); and one for consortium and project management (WP9). All WPs are strongly linked to and interacting with WP7, leading the development of three European roadmaps for the reduction of contentious inputs in organic production:

i. European roadmap for the reduction of contentious plant protection products: copper and mineral oil
ii. European roadmap for the reduction of contentious fertilisers and manures in plant nutrition
iii. European roadmap for the reduction of contentious inputs used in livestock production: antibiotics, anthelmintics and vitamins

The aim of the RELACS European roadmaps is to propose fair, reliable and implementable rules to achieve an identified realistic reduction pathway for each of these six priority contentious inputs.

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[1] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007

[2] Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorising certain products and substances for use in organic production and establishing their lists

The roadmaps have been developed through a multi-actor approach and a fact-based dialogue. As a first step, workshops were organised at national level to present and discuss the alternatives developed within RELACS to relevant stakeholders of the organic sector. Then, the outcomes of the national workshops were presented and discussed during a European workshop. All the outcomes of these workshops provide the basis for the preparation of the three European roadmaps.

3.1 National workshops

21 national workshops were organised in 9 EU Member States (France, Italy, Spain, Bulgaria, Hungary, Germany, Denmark, Estonia, Belgium) and the United Kingdom, gathering practitioners, advisors, national authorities, and scientists (see Figure 3-1 and Annex I), to discuss the pros and cons of alternative tools and techniques developed by RELACS, explore the current acceptance level as well as identify necessary adaptations of current legislation to enable the uptake of these alternatives.

Each workshop focused on one contentious input and its alternatives. Depending on the national context, one or more workshops were organised (see Table 3-1).

The workshops to discuss alternatives to the use of synthetic vitamins could not be organised, because of difficulties in gathering the relevant participants. Unlike all the other workshops of which the main stakeholders are the farmers, the relevant stakeholders to discuss alternatives to synthetic vitamins are the feed mills, which supply both the conventional and organic sectors. Too few of these actors showed interest in participating in a RELACS workshop. This could be explained by the fact that the national networks of feed mills are less developed than the organic farmers' networks, and the fact that they are operating in a competitive market which makes it difficult to create sufficient confidence.

Table 3-1 Overview of national workshops organised by RELACS

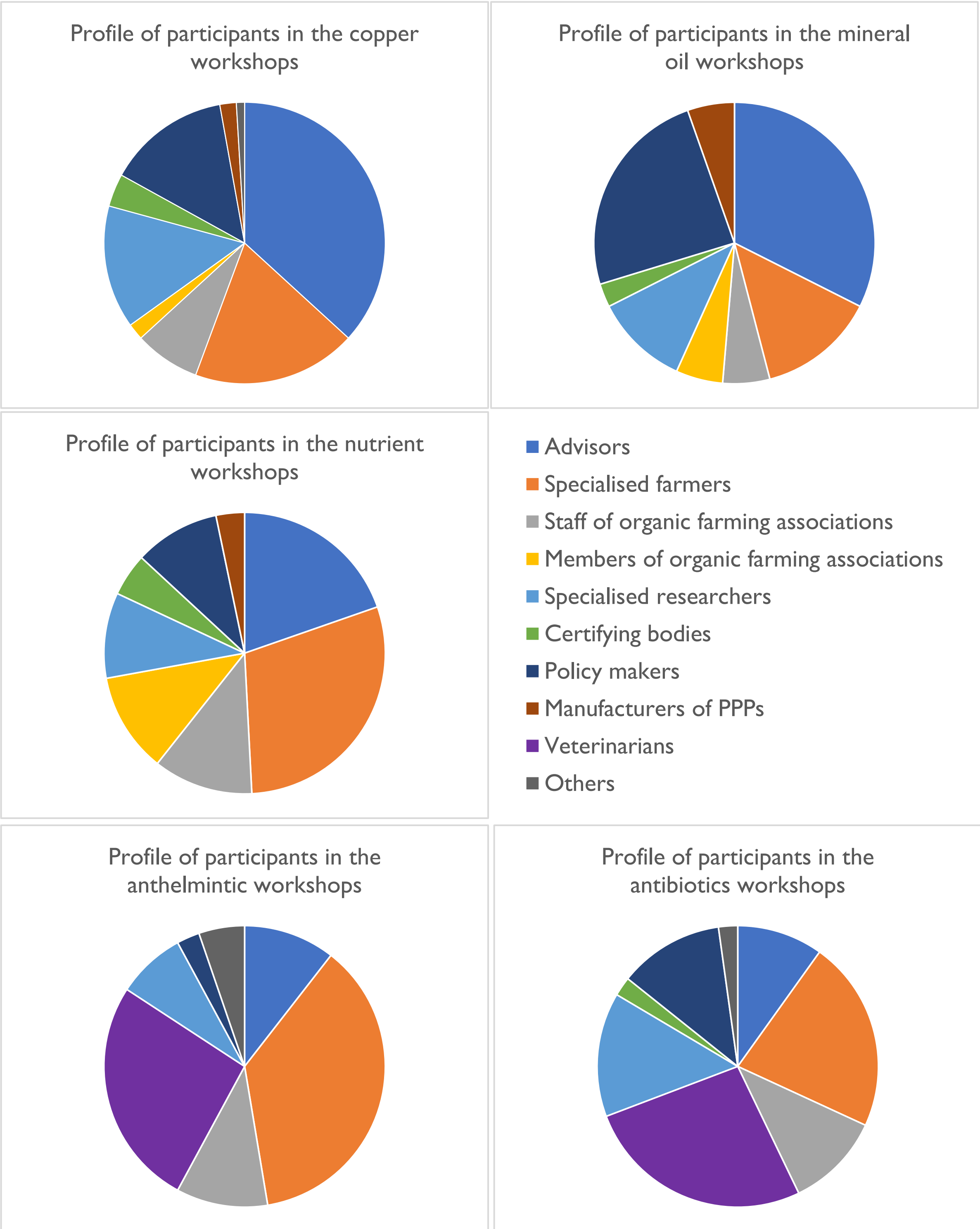
	Copper	Mineral Oils	Nutrients	Anthelmintics	Antibiotics	Vitamins
France					2020 & 2021	
UK	Aug. 2021			June 2021	June 2021	
Hungary	Sept. 2021		Sept. 2021			
Spain	June 2021	June 2021			July 2021	
Italy	May 2021	May 2021	May 2021			
Germany	Sept. 2021		April 2021	April 2021	April 2021	
Estonia			Sept. 2021		Sept. 2021	
Belgium	July 2021					
Denmark			Sept. 2021			
Bulgaria	June 2021					
TOTAL	**7**	**2**	**5**	**2**	**5**	**/**

Technical dossiers on each alternative input or method were prepared by the research and technology development (R&D) work packages (WPs 1-6) and shared with the participants before the workshop. Each dossier provides basic information on the alternative proposed: technical, chemical and physical properties, specification of use, side effects, regulatory status, price and compliance with organic principles.

During the workshops, participants were invited to give their views on the acceptability of the alternatives presented regarding their efficacy, environmental impact, cost/benefit and practical obstacles to their uptake. They were also invited to identify knowledge and advisory needs to enable the uptake of the alternatives. Optionally, participants were also asked to identify regulatory and market aspects that might influence the adoption of the alternatives (registration, regulatory obstacles, scalability, supply chain).

Based on this assessment, the participants had to conclude for each alternative whether it could be accepted to reduce the use of the contentious inputs, and under which conditions. Participants were also asked to propose national recommendations and actions to reduce contentious inputs, elucidate bottlenecks and propose timelines for implementation. The outcomes of the national workshops are compiled in input-specific national roadmaps.

Figure 3-1 Overview of the profiles of the participants in the national workshops



3.2 European workshop

A European workshop took place on the 2nd of December 2021, with the aim to share the conclusions of the national roadmaps and to discuss the actions needed at EU level to help reduce the use of contentious inputs and, more generally, to design fair, reliable and implementable EU rules on the use of inputs in organic production. The workshop was attended by about 50 people. Participants were mainly RELACS and Organic-PLUS partners; few participants were from the European Commission or industry.

A summary of the outcomes of the national workshops was presented to the participants, focusing on the level of acceptance of the alternatives by farmers and the main obstacles to their adoption that were identified. Then, the participants were divided into three working groups corresponding to the topics of the three RELACS European roadmaps (plant protection, nutrients, livestock). Based on the results of the national workshops, they brainstormed on potential solutions at EU level to facilitate the adoption of the alternatives developed by RELACS and considered acceptable by farmers.

The aim of the three RELACS European roadmaps – on the reduction of contentious plant protection products, nutrients, and inputs used in livestock production – is to provide recommendations for the reduction of contentious inputs in organic agriculture based on science and facts and in close discussion with relevant stakeholders through the RELACS national and European workshops.

4. Overview of the EU procedure for the authorisation of fertilisers in organic farming

The Organic Regulation (EU) 2018/848 defines the principles and practices of EU organic agriculture, including the rules on the use of inputs. It establishes that external inputs in organic agriculture are limited to (i) inputs from organic production; (ii) natural or naturally-derived substances and/or (iii) low solubility mineral fertilisers. Additionally, they must be compatible with the objectives and principles of organic production to be authorised. Finally, only products and substances that have been previously authorised in the relevant EU's horizontal legislations can be used in organic production.

Therefore, the authorisation of any new input for organic production must follow two regulatory steps: first, the input has to comply with the corresponding EU's horizontal legislation, then it has to be added to the annexes of the Regulation (EU) 2021/1165 establishing the list of products and substances authorised in organic agriculture.

4.1 Authorisation in the EU horizontal legislation on fertilising products

The new Regulation (EU) 2019/1009[3] on the authorisation of EU fertilising products was adopted in June 2019. It will enter into force in July 2022 and will repeal the former EU Fertiliser Regulation (EC) No 2003/2003[4].

Regulation (EC) 2003/2003 establishes harmonised conditions for making available certain fertilisers on the EU market, as it applies almost exclusively to fertilisers from mined or chemically produced, inorganic materials. It regulates only the characteristics of the final product in a very precise way such as its nutrient levels. Fertiliser manufacturers have the possibility to choose between:

- complying with the EU Regulation to get their products marked as 'EC fertilisers', which can then move freely in the internal market – it is the responsibility of the manufacturer to make sure that a fertiliser labelled as an 'EC Fertiliser' meets the technical and labelling requirements of the regulation,

[3] Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003

[4] Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers

- or applying the national legislation on fertilisers of the Member State where they want to sell their products. In case they intend to place the product on the market of another Member State, they rely on the mutual recognition principle[5].

For other fertilising products (such as organic fertilisers), the conditions for placing them on the market are governed by national laws and the mutual recognition rules apply.

The new Fertilising Product Regulation (EU) 2019/1009 (FPR) brings two main novelties:

(i) The scope of harmonised rules is expanded to a wide range of fertilising products such as organic fertilisers, organo-mineral fertilisers, soil improvers, inhibitors, growing media or blends and plant biostimulants, which will open the EU market to these products.

(ii) Requirements are established for both the final characteristics of the product (e.g. nutrient levels, contaminant limits) and the input materials composing the fertilising products.

The FPR will exist in parallel to national legislation and mutual recognition as it is only creating an optional harmonisation. This means that manufacturers will still have the choice between marketing their product as "EC fertilisers" (and therefore complying with the FPR requirements) or marketing their product at Member State level (and therefore complying with national rules and using mutual recognition rules to extend their trade to other Member States).

4.2 Authorisation in the Organic Regulation

Annex II of the Implementing Regulation (EU) 2021/1165 establishes the list of fertilisers, soil conditioners and nutrients that may be used in organic production, "provided that they are compliant with the relevant Union and national legislations on fertilising products, in particular, where applicable, Regulation (EC) No 2003/2003 and Regulation (EU) 2019/1009; and Union legislation on animal by-products, in particular Regulation (EC) No 1069/2009 and Regulation (EU) No 142/2011, in particular Annexes V and XI."

To be included in Annex II, fertilising materials or products fulfilling the above-mentioned provisions must undergo an assessment process to ensure that they comply with the principles of organic farming.

It is the Commission that decides on the addition of an active substance to Annex II, more precisely the "Organics" Unit of DG AGRI. Member States can submit to the Commission requests to do so. Before taking its decision, the Commission receives advice from the expert group for technical advice on organic production (EGTOP), which is a permanent group of the Commission composed of independent scientists and other experts from EU countries with competences related to organic production.

The EGTOP assists the Commission by assessing for each material the compliance of the following criteria with the objectives and principles of organic production:

- Necessity for intended use and known alternatives
- Origin of raw material and manufacturing process
- Environmental issues, use of resources, recycling
- Animal welfare issues
- Human health issues
- Food quality and authenticity
- Social, economic, and ethical concerns

Based on this technical evaluation, the EGTOP also provides non-binding recommendations on the authorisation of the substance for organic production. There is no pre-established logic for weighting the criteria against each other. The expert group follows a holistic approach and decides on a case-by-case basis.

The Commission generally follows the EGTOP's opinion. Any Commission's proposal concerning the authorisation of a new fertilising material for organic production (meaning its inclusion in Annex II) is submitted for approval by

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[5] The principle of mutual recognition stems from Articles 34-36 of the Treaty on the Functioning of the European Union and is further defined in Regulation (EU) 2019/515 on the mutual recognition of goods lawfully marketed in another country.

the Committee on Organic Production, composed of representatives of EU Member States. The Commission's proposal may specify more restrictive conditions for the use of the product in organic production than those established for the use in conventional farming – in the horizontal legislations on fertilising products.

4.3 Toward a progressive alignment between horizontal and organic regulation?

As the horizontal legislation on fertilisers only creates optional harmonisation, it should be possible for a fertiliser to be included in Annex II of the Organic Regulation 2021/1165 even if it is not registered under Regulations (EC) No 2003/2003 and/or (EU) 2019/1009.

However, in recent years there has been a gradual alignment between the organic regulation and horizontal regulations governing the authorisation of agricultural inputs. In the case of fertilisers, the inclusion in the Annex of the Organic Regulation of new materials encompassed by the Regulation (EC) 2003/2003 has been conditioned in some cases to their previous authorisation under Regulation (EC) 2003/2003 – especially for materials that undergo physical, chemical or biological treatment.

For instance, in 2016, the EGTOP concluded that struvite and renewable calcined phosphate should be included in the list of authorised fertilisers for organic agriculture, if they were first authorised under Regulation (EC) No 2003/2003[6]. Since the new Fertilising Products Regulation 2019/1009 will cover more fertilising products, it might be expected that the inclusion of new materials in Annex II of Regulation (EU) 2021/1165 becomes more and more determined by a previous registration under the horizontal legislation.

It is interesting to note that in Regulation (EU) 2021/1165, the wording regarding the requirements with which fertilisers must first comply before they can be authorised for organic production leaves room for interpretation, as it states: "provided that [these fertilising products] are compliant with the relevant Union **and** national legislations on fertilising products, in particular, **where applicable**, Regulation (EC) No 2003/2003 and Regulation (EU) 2019/1009". This might be interpreted as an obligation for fertilising products to comply with the EU horizontal Regulations, even if this is supposed to be optional.

If compliance of fertilisers for organic farming with the EU horizontal regulation becomes the norm, the approval procedure for these products can be expected to become longer and more complex, due to additional scientific data requirements, costs and administrative tasks. From a technical point of view, difficulties may emerge to match the safety criteria for recycled fertilisers because of the variable composition of the raw materials (waste, organic co-products...).

5. Phasing-in new recycled nutrient sources

5.1 Problems associated with contentious nutrient sources

To maintain and increase soil fertility, organic farmers carefully manage nutrient cycles on-farm through crop-rotations and the use of nitrogen fixing plants, as well as the use of animal manure. However, in practice, organic arable farming is often decoupled from animal husbandry, thus macronutrients like N, P and K are not available in appropriate amounts, and therefore they need to be supplied via external sources (Løes et al. 2017). The import of nutrients is particularly necessary to maintain yield levels on farms with little or no livestock.

Among the external inputs used for organic plant nutrition, manures from non-organic farms and rock phosphates are considered the most problematic due to contaminants, the usage of non-renewable sources as well as the structural dependency on conventional farms (Oelofse et al. 2013; Cordell & White, 2011). But according to expert opinions mapped in a RELACS study[7], some commercial fertilizers such as feather meal from large scale poultry production are also considered as problematic.

[6] EGTOP Final Report on Organic Fertilizers And Soil Conditioners (II), 2016

[7] Internal report on the current use of and need for external nutrients in eight case study regions in Europe: Denmark, United Kingdom, Germany North, Germany South, Italy, Hungary, Estonia and Switzerland

Although organic agriculture seeks to decrease reliance on external nutrients sources, organic farmers in different contexts still rely on the import of nutrients from conventional agriculture to varying degrees. There has been limited work undertaken across Europe that directly quantified the reliance of organic farms on conventional nutrient sources. The few studies undertaken have shown that organic farms, especially stockless ones, rely on animal manure from conventional farms to fulfil their nutrient needs, in particular the supply of P and K (Foissy et al, 2013; Oelofse et al, 2013; Nowak et al. 2013; Gosling and Shepherd 2005). These observations are confirmed for Denmark, Hungary and Italy by a study undertaken in the RELACS project, on nutrient management strategies and reliance on external inputs in a variety of countries and contexts (the internal report mentioned above). The study shows that whilst on an aggregated level across all farms N was in surplus and P and K were relatively balanced, it was evident that more than half of the farms surveyed had negative P and K budgets. Ensuring supply of P and K in organic farms is thus a challenge. Biological nitrogen fixation remains an important source of N in organic farms. The utilization of external inputs varied widely across locations, often reflecting the levels of land-use intensity. The use of nutrient inputs from recycled products was most prominent in Germany and Switzerland. 'Conventional manure' (viewed as a contentious input) was an important nutrient input especially in Denmark, Hungary and Italy. Rock phosphate was not used on any of the farms.

Reducing the use of conventional manure in organic farming systems is challenging because on the one hand it could increase the risks of mining the soil – especially in stockless farms – and on the other hand, it would further reduce the productivity per area.

The EU has set a target to reach 25% of agricultural land under organic farming by 2030. Additional nutrient sources are needed to support the expected growth of the organic sector while reducing the use of contentious external nutrients. The use of recycled fertilizer from urban waste could help in lowering the reliance of the organic sector on manures from conventional farming while also closing the nutrient cycle between urban and rural areas. However, first the recycled fertilizers need to be evaluated in respect to their yield effect, nutrient efficiency, resulting nutrient budgets, environmental impact, especially N losses and accumulation of potentially toxic elements (PTEs), and their effect on soil fertility in the short and long term. Matching regional demand with local availability of nutrient sources is a prerequisite to operate resource-efficiently, since organic matter-based fertilizers are notoriously bulky.

5.2 Tools and techniques assessed by RELACS

The RELACS project has contributed to open pathways to alternative sources of plant nutrition needed to reduce the dependency on contentious fertilizers and manures in plant production. To do so, RELACS has analysed opportunities for new technologies to recycle nutrients from waste streams for organic agriculture, focusing on three recycled inputs: struvite, anaerobic digestates and calcined sewage sludge ash.

The main characteristics of these three recycled fertilisers are presented in the following sections.

5.2.1 Anaerobic digestates

Description	Anaerobically digested organic wastes from various origin (biowaste, green waste, food waste). Often separated into a liquid phase (2-12% dry matter) and a solid phase (non-dried solids: 20-30% dry matter, and dried solids: 60-86%). Solid digestates often subjected to composting.
Type of use	Organic multi-element fertilizer Liquid digestate: medium-fast N releasing fertilizer for soil application Solid digestate: slowly N releasing fertilizer for soil application
Nutrient content	Liquid digestates: 4.5-12% N, 0.7-1.2% P, 3-4% K. Solid digestates: 2-3% N, 0.6-0.9% P, 1.2-1.3% K. Both liquid and solid digestates also contain all other macro- and micronutrients as well as carbon.

Mode of action	Liquid digestate contain 50-70% of total N in the form of ammonium, therefore show immediate effects on plant N uptake. Solid digestate contain up to 40% of total N in the form of ammonium, and usually have a N fertilizer value of up to 30% of total applied N in the year of application, with a net mineralization in the following years of 2-8%. Both liquid and solid digestates improve soil properties such as water infiltration capacity, soil organic carbon, microbial activity and soil pH.
Side effects	N in liquid and solid digestates is prone to ammonia volatilization. Accumulation of potentially toxic elements (PTEs) is prevented by the threshold values in the Regulation (EC) 2021/1165. Most relevant elements are copper and zinc, which have a dual role in the soil as potential pollutant and essential nutrient. Accumulation of PTEs with regular application of digestates is typically lower than with regular application of conventional pig slurry or household or green waste composts. Concentrations of persistent organic pollutants in digestates are very low.
Historic of use & regulatory status	Organic wastes have traditionally been processed for reuse as fertilizer by composting. Application of compost has a long tradition in general agriculture as well as organic agriculture. Processing of these wastes by anaerobic digestion is a more recent technology. The annex II of the EU Regulation (EC) No. 2021/1165 authorises the use of various digestates, namely: • Liquid animal excrements after controlled fermentation • Fermented mixture of household waste • Fermented mixture of vegetable matter • Biogas digestate containing animal by-products co-digested with material of plant or animal origin as listed in this Annex. Food waste (retail or catering) and organic waste from food processing are not explicitly mentioned, leaving room for interpretation.
Origin of raw material & production method	A variety of organic materials can be digested, e.g. manure, green waste of agricultural origin, sewage sludge, organic waste from food industry, urban organic wastes – which include green waste from gardens or park areas, source-separated food waste from private households, food waste from retail or catering and organic waste from food processing). Available amounts of urban organic wastes are approximately 100 kg per person and year. Anaerobic digestion is a thermophilic fermentation of mixed and shredded organic wastes in biogas plants. Biogas is produced by the microbial breakdown of organic material in the absence of oxygen. Digestates are the remainder of the original input material. Processing chemicals are sometimes added during anaerobic digestion, including lime, zeolithe and iron chloride. During digestion, most weed seeds lose their ability to germinate, and the pathogen load is largely reduced. GHG emissions and N losses are lower during anaerobic digestion than during composting.
Scalability	Depends on the development of biogas plants.
Costs	Price competitiveness over organic commercial fertilizers, at least in horticultural crops.

5.2.2 Struvite

Description	Precipitate obtained by applying Ostara's Pearl® process to wastewater
Type of use	Slow-release P fertilizer for soil application. Solid granules, ∅ = 0.9, 1.5 or 3.0 mm.

	Sparingly soluble in neutral and alkaline, but readily soluble in acid conditions.
Nutrient content	5% nitrogen (N), 28% phosphate (P_2O_5), 10% magnesium (Mg)
Mode of action	Slowly dissolved in soil and becoming plant-available over time.
Side effects	On crops, similar to those of other slow-release P fertilisers. On the environment: • Struvite does not add new P to the cycle as it originates from recycling • The risk of P, N and Mg leaching from struvite after application is low • Soil quality is not affected by struvite application • Soil pollution with Cadmium is avoided • Struvite production needs to be combined with other P recycling approaches because P recovery from wastewater is low (22%)
Historic of use & regulatory status	Not traditionally used in organic agriculture. But…: • wastewater has been traditionally applied to agricultural land; • the use of recycled nutrients from various sources outside organic production, including industrial processes, is widespread in organic production. Struvite is not yet permitted as a source of phosphorus in organic farming. The Expert Group for Technical Advice on Organic Production (EGTOP) advised in a 2016 report that struvite should be authorised in organic production without further consultation once it is authorised under EU horizontal legislation on fertilisers. This will be the case as from July 2022, when the new Regulation (EU) 2019/1009 on Fertiliser Products will become applicable. Struvite is then expected to be included in the annex of the EU Organic Regulation listing the fertilisers authorised in organic farming, on the occasion of an update of this list.
Origin of raw material & production method	Struvite is recovered from wastewater. In the EU, there are about 50.000 municipal and industrial wastewater treatment plants which generate over 11 million tons dry mass of sewage sludge waste every year Precipitate produced by treating the liquid phase after sludge dewatering at wastewater treatment plants (Ostara's Pearl® process). The liquid phase is treated with enhanced biological P removal, i.e. using microorganisms to remove P from the liquid phase. Addition of MgCl2 and pH adjustment by addition of NaOH lead to precipitation and crystallisation of struvite. The overall risk for pollution is reduced as struvite production process removes P and N from wastewater, but the production of MgCl2 and NaOH may potentially cause emissions.
Scalability	Struvite can be produced locally, wherever there is a wastewater treatment plant.
Costs	About 1200 € / MT at farmers gate in Europe

5.2.3 Calcined sewage sludge ash

Description	Calcined sewage sludge ash (Rhenania phosphate) obtained by applying the AshDec® process to sewage sludge ash.
Type of use	P fertiliser for soil application. Granular, with approximately 80% < 0.5mm ∅ (depending on input material). Not water soluble, but highly soluble in neutral ammonium citrate.

Nutrient content	20,0 % P2O5 - Total Phosphate 0,06 % Cu - Total Copper 0,07 % Mn - Total Manganese 0,15 % Zn - Total Zinc 10 % Fe - Total Iron
Mode of action	Plants can access the phosphorus by releasing root exudates.
Side effects	On crops, similar to those of other P fertilisers. On the environment: No pathogens, endocrine disruptors, hormones or other pharmaceuticals remain after the manufacturing process (incineration of the sewage sludge (at 850 °C - 900 °C) followed by thermal treatment (850 - 900 °C) of the ash). The content of heavy metals, zinc and copper in the final product will meet all legal requirements if sewage sludge ash with heavy metal concentrations within common ranges will be used.
Historic of use & regulatory status	Not traditionally used in organic agriculture (new technology). But…: • sewage sludge has been traditionally applied to agricultural land and the recovery of nutrients from animal excrements (manure) is a traditional organic practice; • the chemical composition of this secondary P fertilizer from sewage sludge ash is similar to Rhenania phosphate fertilizer which was used in the first half of the 20th century. Calcined sewage sludge ash is not yet authorised in organic production. Thermal oxidation products from sewage sludge ash will be registered under the new EU Regulation on Fertiliser Products 2019/1009 (will be included in CMC 13). In 2016, EGTOP gave a positive opinion for its inclusion in the annex of the organic regulation when it is (i) produced from municipal waste water sludge; (ii) Cr (VI) not detectable and (iii) other heavy metal contamination is minimised.
Origin of raw material & production method	Recovered from sewage sludge ash (SSA) which is the residue of the incineration of sewage sludge. In the EU: about 50.000 municipal and industrial wastewater treatment plants which generate over 11 million tons dry mass of sewage sludge waste every year. AshDec® is a thermochemical process that converts low plant-available phosphorus compound in sewage sludge ash (Ca3(PO4)2) into high plant-available phosphorus compound (CaNaPO4) while reducing heavy metal content via evaporation. Ash is mixed with sodium compounds and a reducing agent (preferably sewage sludge) in a rotary kiln (900 °C for 15-20 min). Sodium ions replace calcium ions in the phosphates and form Rhenania phosphate: citrate-soluble CaNaPO4 compounds. A noticeable high amount of heavy metals in their elemental form evaporate at the prevalent temperatures. The flue gas from the plant is treated to comply with emission limits. The material produced is cooled and processed in a specific plant to obtain the final fertiliser product. The process recovers >95% of P in sewage sludge.
Scalability	High amount of row material is available. Calcined sewage sludge ash can be produced locally, wherever there is a wastewater treatment plant.
Costs	No information available

5.3 Farmers’ acceptance level of the alternatives proposed by RELACS

The acceptance level by farmers for the recycled fertilisers researched by RELACS was assessed during the RELACS national workshops (see section 3.1) taking place in Denmark, Estonia, Germany, Hungary, Italy.

As a starting point, participants generally stressed the importance of biological N-fixation to ensure the nutrient supply of the farms, but they also agreed that the expected growth of organic farming is likely to require more nutrient sources. They stressed the importance of the circular economy to produce recycled fertilisers in line with organic farming principles.

In general, the acceptance level of farmers for the three recycled fertilisers presented by RELACS is good. The main bottlenecks to accept these alternatives are the uncertainties regarding the level of contaminants and the higher prices. A majority of farmers is willing to pay slightly more for a recycled fertiliser product, but only if the purity of the product is ensured, which means no contaminants or pollutants. Furthermore, farmers will only pay substantially more for recycled fertilisers that are certified 'all organic' (as opposed to mineral components) which is rarely the case.

For **struvite**, farmers recognise the high efficacy of this product to provide P. The production process seems to offer sufficient guarantees regarding the level of contaminants in the end product. The fact that struvite received a positive opinion from EGTOP for its inclusion in the list of fertilisers authorised in organic production is also a sound guarantee. The main concern of farmers is the price of struvite, which they consider to be too expensive. Upscaling the production of struvite could help to lower the price in the short term and facilitate its adoption by farmers.

Calcined sewage sludge ash also has a good efficacy according to farmers, but they would like to have more information on the level of residues in the end product, especially microplastics and organic residues. Further research is needed for this. In addition, some farmers believe that the high energy consumption of the production process is a problem regarding the principles of organic farming, which require a rational use of resources.

Anaerobic digestate is already authorised in organic farming. Farmers are used to it and recognise that it is at least as effective as conventional manure. Farmers are willing to use anaerobic digestate, although they are concerned about the presence of residues and microplastics, and would like to see further research to ensure that digestates are safe for the soil. Some farmers are also concerned about the higher risk of N leaching and ammonia losses with liquid digestate and would prefer using only the solid phase. Another key point raised by farmers is the necessity to ensure that the production of raw materials and substrates used for anaerobic digestion is compliant with the organic principles and rules. The fact that food waste is not explicitly mentioned in the organic regulation as source authorised for anaerobic digestion creates uncertainties. Finally, using digestate can entail significant investment in transport equipment and storage facilities, which might discourage farmers.

The national workshops showed the importance to consider **regional variations and needs** regarding nutrient supply of organic farms. In Denmark, Germany and Hungary, the conclusions of the workshops show that there is no substantial demand for pure P fertilisers in these countries, since very few farms are concerned by P depletion. In these countries, farmers would prefer to supply P through a more complete nutrient source, such as digestate or compost, also containing organic matter and other nutrients. Furthermore, Hungarian farmers stressed that sewage sludge ash is not adapted to their local conditions, because of its high sodium concentration that will further increase salinisation of their soils. A regional approach is therefore key to reduce the use of contentious fertilisers.

5.4 Obstacles to the adoption of the alternatives

Whether in terms of scientific results or acceptability by farmers, the recycling technologies assessed by RELACS show a good potential to be integrated into organic nutrient supply strategies. However, several obstacles to their adoption by farmers were identified.

The first barrier is of **regulatory nature**. There are no clear provisions in the EU Organic Regulation regarding the conditions under which recycling of societal waste can be considered as compliant with the principles of organic farming. Important aspects need to be clarified, such as the sources of waste that are acceptable, the production process (in terms of energy consumption, additives), the quality of the end-product, or even the possibilities to certify compliance of the product with the organic rules. The quality of the waste source can vary greatly from country to country, making it difficult to establish harmonised rules for the quality of the final product. Without a clear regulatory framework, it is difficult to include new external inputs in Annex II of the Organic Regulation. This situation could explain why the EGTOP requires compliance of recycled fertilisers with the EU horizontal legislation on fertilisers as a preliminary condition, to ensure at least that safety requirements are met, and the production process is well regulated.

The potential presence of **contaminants** in the recycled fertilising products is also a major issue to be solved, as farmers will only use such products if they are sure they are safe. First, it is very challenging to trace the huge variety of potential contaminants in recycled products, and it is even more difficult to know their impact on the environment, the soil, food safety and human health. There is a lack of clear guidance concerning what levels of contamination (of various sorts) are harmful. Further research is needed to solve these issues. **Consumer perception of risk** is also related to the uncertainties around the presence of contaminants and their potential impacts. They will need to be reassured with a protective regulatory framework based on sound scientific studies.

Another obstacle to the development of the use of recycled fertilisers in organic agriculture is the **availability of materials for recycling,** which varies according to regional contexts. Moreover, the development of the circular economy is likely to increase competition on access to bio-based materials. Overall, this could result in a lack of recycled material for organic farming, and ultimately a low availability of recycled fertiliser in some regions. The development of recycled fertilisers will also need good **infrastructure** (transport, storage) and **well-developed supply chains**.

Apart from anaerobic digestates, recycled fertilisers remain not very well-known by farmers and suffer from poor advice related to their use. Farmers are not always aware of the risk of soil nutrient depletion in the long term. This is linked to a lack of knowledge about the balance of soil nutrients. In addition, farmers are not always aware of latest research on recycled fertilisers and remain sceptical about contaminants and potential effects on soil organisms. Finally, recycled fertilisers are likely to be more expensive and have other characteristics than conventional manure or rock phosphate. Their adoption by farmers will require additional efforts, in terms of costs and practical support.

5.5 Strategies to overcome the obstacles

5.5.1 Already existing initiatives to reduce contentious nutrients and phasing in recycled fertilisers: the case of Denmark

In 2008 Danish organic farmer organisations decided to phase out the use of manure and straw from conventional farms by 2021. This is a double challenge for the Danish organic sector because in 2012, the Danish Ministry of Food, Agriculture and Fisheries published an Organic Action Plan with the aim to double the national organic area by 2020 (compared to 2007).

In 2015 it was decided to slow down the phasing out due to the lack of acceptable alternatives. Instead, a more gradual approach to replenishing fertility from alternative sources was adopted. A principle agreement was achieved to prefer recycled 'safe' societal resources over conventional manures and straw. This decision was supported by the publication of a study in 2013 (Oelofse et al, 2013) of possibilities for phasing out, concluding that it will be impossible to cover the need for P fertilization in Danish non-dairy farms without resorting to sewage sludge.

In 2018 the Danish Organic Business Development Team recommended that organic farmers be allowed to utilise nutrients from treated domestic wastewater for nutrient recycling provided that it is deemed safe and acceptable for consumers. The organic farmer organisations have asked the Food and Agriculture ministry to work towards the legalisation of using sewage sludge subject to quality criteria (based on the risk assessment comparing contemporary conventional animal manure and sewage sludge). Magid et al (2020) assessed that the risk of agricultural use of contemporary Danish sewage sludge is similar to that of pig slurry, once the EU limits for use of Zn and Cu in fodder have been fully implemented.

In 2020, organic farmer organisations have voluntarily decreased the maximum permissible amount of conventional manure, and increased incentives for using recycled products. This is mainly possible thanks to the development of anaerobic digestion plants. The number of plants will increase substantially in the coming years.

To consolidate this approach, further research is ongoing into consumer acceptance of nutrient recycling as well as detailed research on recycling technologies and ecosystem health.

5.5.2 RELACS policy recommendations to support the phasing-in of new sources of recycled nutrients

The organic regulation should be adapted to the increased demand for recycled fertilisers by clarifying the conditions for authorisation and use of such fertilisers in organic farming. It will be necessary to **update, agree and adopt an evaluation framework for compatibility of external nutrient inputs with the principles of organic production**. This framework should propose an overall evaluation, covering fitness for purpose, responsible sourcing, assessment of the production process, and assessment of potential pollution. The development of such framework should start with **discussions within the organic sector**, to reach a common position on acceptable recycled fertilisers for organic production. This process will start by launching **a working group coordinated by IFOAM Organics Europe**. Once the organic sector will have a common position, a dialogue should be started with EU policymakers on how to design fair and responsible rules for the use of recycled fertilisers in organic farming. The **Integrated Nutrient Management Action Plan** that will be presented by the European Commission in 2022 could offer the right platform to have this discussion. Ensuring the compatibility of digestates with organic farming rules, ensuring separate waste collection and covered by a certified production process, would facilitate the adoption of this input by farmers.

Further research is needed to ensure that the proposed recycled fertilisers are both yield efficient and environmentally safe. Future research should focus on long-term experiments in different regions/climates, to evaluate the effects of various materials on yields, soil and plant health, and determine the fate of **contaminants**. Research should also focus on reducing the source of contamination where it is known. For example, with regard to heavy metals in agricultural soils, Zn and Cu are of concern and mainly come from mineral feed supplements that end up in animal manure. It will also be necessary to **map nutrient needs and available resources** for better spatial distribution of nutrient recycling plants, in particular biogas plants.

Increasing **separate household waste collection** could avoid the presence of contaminants in the waste source, facilitate the production process, enable a better traceability and ensure the safety of the recycled fertiliser and its compliance with the principles of organic production. These aspects should be reflected in the upcoming **European Commission's proposal to harmonise separate waste collection systems**, taking account of regional and local conditions. This initiative was announced in the **EU Circular Economy Action Plan** and is expected for 2022. Going on step further, food packaging should be redesigned to avoid contamination of food waste (e.g. less plastic packaging).

The **whole supply chain** should be considered to further develop recycled fertilisers. Significant investment will be needed to develop the infrastructure, so it is important to stimulate demand and ensure there are outlets for recycled products. A **multi-actor approach** involving manufacturers, farmers, advisors and policymakers would ensure that the development of the value chain meets the expectations of all stakeholders. Such an approach would also improve knowledge exchange and transfer between all actors (farmers, researchers, industry, policy).

Farm advice on nutrient balances should be intensified**.** This will be the first step in clearly identifying the nutrient needs of farms, and checking if nutrient management strategies need to be adapted. Increasing the use of '**farm gate nutrient budgets**' can contribute to this objective. Farm gate nutrient budgets are an easy and efficient tool to assess the main nutrient flows in and out of the farm. They can reveal whether there is a nutrient surplus or deficit. Thus, they help farmers to adjust nutrient inputs to achieve a balanced nutrient budget. RELACS has developed a Practice Abstract[8] on how to calculate a farm gate nutrient budget, which can help disseminate this tool among farmers.

Targeted advice can help raise awareness of nutrient gaps and increase interest in recycled fertilisers. Regional conditions must be taken into account. The **Common Agricultural Policy** provides the necessary tools to support training, peer-to-peer learning, advisory sessions, and exchange schemes. Member States must allocate sufficient resources to these advisory services in their national strategic plans. The Common Agricultural Policy can also provide financial support for the adoption of recycled fertilisers, either by supporting investments on farms

[8] Farm gate nutrient budgets for organic farming – RELACS project, available at: https://relacs-project.eu/wp-content/uploads/2021/05/RELACS_PA_03_nutrient_budget_UH_UK_FiBL_final.pdf

(storage facilities, equipment) or via direct support for organic farmers who are committed to reducing conventional inputs.

5.6 Pathways for reducing contentious nutrient sources and phasing in recycled fertilisers

The RELACS project has shown that the importance of nutrient supply in organic farming has been underestimated so far. Current soil fertility management of organic farms may pose a risk either for soil fertility as indicated by negative balances, or for the environment due to high surpluses. In addition, the extent of 'dependence' on conventional sources may appear low at the aggregate level, but there are significant inter-regional variations, and some production systems remain highly dependent on external sources of N besides biological nitrogen fixation, such as stockless arable and low animal intensive farms.

Reducing the dependence of organic farms on conventional manure and external nutrients from non-renewable sources is nevertheless possible in the medium term, but it needs to be well prepared considering the potential risks to the soil and the environment.

A first step in this direction will be further development and research into the recycling of societal waste streams, as recycled fertilisers can help to substitute fertilisers from conventional origin to some extent. Moreover, recycling is in line with organic principles. Research should provide more guarantees on the safety of recycled products, especially with regards to contaminants and microplastics, to make them more acceptable to farmers. In parallel, the organic sector will have to agree on the criteria for determining whether a recycled fertiliser is compatible with the principles of organic farming. The Organic Regulation will then have to evolve to reflect these developments.

The development of recycled fertilisers for organic farming will require significant financial and logistical support, as it requires in some cases redesigning waste collection systems. It is fully aligned with the circular economy policies aiming to recover waste. The distribution of the production costs of recycled fertilisers should be fairly balanced so that the final products remain affordable for farmers.

Another key element for a resilient nutrient management strategy in organic farming is to develop easy and efficient tools to assess the main nutrient flows in and out of the farm, such as the **farm gate nutrient budgets**. Such tools allow to understand the farming system and to adjust its nutrient inputs to achieve a balanced long term supply of all nutrients. This approach can also be extended to conventional farms.

Finally, reducing the use of external nutrients in organic farming requires a regional approach to nutrient management, in order to adapt sourcing strategies to what is regionally available.

6. Discussions

While the Farm to Fork strategy sets a growth target for the organic sector, it also contains a target to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This is supposed to lead to a reduction of the use of fertilisers by at least 20% by 2030. Given the increasing demand for organic products and the resultant increase in nutrient needs, soil fertility management in organic systems is expected to be under increased policy scrutiny in future. In terms of sustainable soil fertility management organic production standards demand, as a minimum, that nutrients removed from the system through harvest shall be replaced by biological N-fixation, recycling, regeneration and/or addition of organic materials and nutrients. However, given that considerable nutrient exports are unavoidable, organic farms will inevitably require a degree of import of nutrients for replacement. Future policy initiatives related to soil fertility management should reflect this point inherent in the functioning of all production systems, not just organic systems.

Finally, when considering the dependence of organic farms on external nutrients, it is important to stress that the nutrient demand of farming systems is related to the desired production intensity. The most intensively managed stockless organic farms are also the most dependent on external inputs. Thus, the challenge of soil fertility in organic farming (and beyond) is not only about nutrient supply, but also about the level of land-use efficiency. The latter remains a matter of farmer choice, especially depending on the production system (arable, mixed), but the flexibility of choice is often limited by market and profitability constraints. Political conditions – structured mainly by the Common Agricultural Policy – also significantly influence farmers' production choices.

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Annex I – Number and composition of participants in the national workshops

Number and composition of participants in the copper national workshops

	Belgium	Bulgaria	Hungary	Italy	Spain	UK
Advisors	2	20	3	6	4	4
Specialised farmers	5	4	3	3	3	2
Staff of organic farming associations	1	/	1	4	/	2
Members of organic farming associations	/	/	/	2	/	/
Specialised researchers	3	4	1	4	1	2
Certifying bodies	/	2	/	/	/	2
Policy makers	/	/	/	13	/	2
Manufacturers of PPPs	/	1	/	1	/	/
Others	/	/	/	/	1	/
TOTAL	**11**	**31**	**8**	**33**	**9**	**14**

Number and composition of participants in the mineral oil national workshops

	Spain	Italy
Advisors	4	8
Specialised farmers	1	4
Staff of organic farming associations	/	2
Members of organic farming associations	/	2
Specialised researchers	2	2
Certifying bodies	/	1
Policy makers	2	7
Manufacturers of PPPs	/	2
Others	/	/
TOTAL	**9**	**28**

Number and composition of participants in the nutrient national workshops

	Germany	Denmark	Hungary	Italy	Estonia
Advisors	2	2	4	4	NA
Specialised farmers	6	6	2	4	NA
Staff of organic farming associations	2	3	/	2	NA

Funded by the European Union

Members of organic farming associations	/	6	/	1	NA
Specialised researchers	2		2	2	NA
Certifying bodies		1	/	2	NA
Policy makers	1	1	/	4	NA
Manufacturers of fertilisers	/	/	/	2	NA
TOTAL	**13**	**19**	**8**	**21**	**NA**

Number and composition of participants in the anthelmintic national workshops

	Germany	UK
Advisors	2	2
Specialised farmers	4	10
Staff of organic farming associations	2	2
Veterinarians	2	8
Specialised researchers	1	2
Policy makers	1	/
Others	/	2
TOTAL	**12**	**26**

Number and composition of participants in the antibiotic national workshops

	Germany	UK	Spain	France
Advisors	2	2		5
Specialised farmers	4	10	2	4
Staff of organic farming associations	2	2	1	5
Veterinarians	2	8	4	10
Specialised researchers	1	2	5	5
Certifying bodies	/	/	/	2
Policy makers	1	/	/	10
Others	/	2	/	/
TOTAL	**12**	**26**	**12**	**41**