Events **1**
Future of Phosphorus Removal in Wastewater 2021 1
How to register fertilisers in different countries 1
PERM presentations and videos now online 1
ESPP new member: OCP **2**
EU Fertilising Products Regulation **2**
New proposals for by-products 2
Slow progress Animal By-Products, progress on other points 3
Call for data on pathogens / safety of recovered ammonia / sulphur 3
EU tender for study on fertiliser and mulch polymer biodegradability 3
Policy **4**
European Commission takes Member States to court over sewage treatment 4
SYSTEMIC policy proposals to open markets for recycled nitrogen 4
Legacy Phosphorus **4**
Frontiers in Earth Science special on 'Legacy Phosphorus' 4
Soil P above agronomic recommendations does not increase yield 5
45 years of P fertilisation does not increase total soil P 5
Focusing only on decreasing soil P will take 26-65 years to reach environmental P targets 5
Initial soil P level defines maize productivity 5
Mineral fertiliser offers better P-balance than phosphate rock 6
Mineral fertiliser offers better crop yield than phosphate rock 6
IFA Smart&Green **6**
Research and science **8**
Will atmospheric P deposition significantly impact peat bog carbon storage? 8
Field trials of animal bone char as fertiliser 8
Pyrolysis reduces availability of phosphorus in poultry manure 9
Struvite effective fertiliser with lower P-loss risk 9
Global Phosphorus Institute launched 9
Stay informed **9**
ESPP members **9**

Events

Future of Phosphorus Removal in Wastewater 2021

7th July 2021, 10h30 - 16h30 CEST. Online conference will look at current status and future developments in phosphorus removal from wastewater, P-stewardship and P-recovery. Speakers include the UK Environment Agency, Isle Utilities, I-PHYC, The Rivers Trust, several UK water companies, ESPP.

https://event.wwtonline.co.uk/phosphorus/

How to register fertilisers in different countries

29th June 2021 13h-15h CEST – free webinar organised by Fertiliser Consultants Network (FCN). Key points of the new EU Fertilising Products Regulation. How to manage fertiliser registration in the transitional period 2021-2024. Specific country/regional registration: France, Greece, Romania, North Africa, India,

Programme and registration https://www.legera.eu

PERM presentations and videos now online

Speaker slides and the 'Chat' from the 4th Phosphorus in Europe Research Meeting (PERM) are now online here and the video recordings of the event are available on YouTube here.

Over 370 participants took part in the 4th Phosphorus in Europe Research Meeting (PERM) 2nd June 2021 online, organised by ESPP, Biorefine and ETA. The meeting provided a showcase to policy makers and companies of R&D underway into nutrients in Europe, enabled exchange of experience between R&D projects.

PERM4 is accompanied by a full update of ESPP's inventory of nutrient-related R&D projects now online here www.phosphorusplatform.eu/R&D

PERM4 web page: www.phosphorusplatform.eu/PERM4

ESPP new member: OCP

OCP Group, a leading, global producer of phosphate and fertiliser, was founded in 1920 to manage Morocco's phosphate reserves, and is today focussed on sustainable agriculture. OCP's purpose and mission is to "*maximize the positive impact of phosphorus*". The company's Phosphate Stewardship Policy underlines its strong commitment to sustainably managing Morocco's phosphate resource and is aligned with the UN's 2030 Agenda and the Sustainable Development Goals, specifically SDG 12: "*Ensure sustainable consumption and production patterns*". Sustainable phosphate management is applied across OCP's operations and sites; through product innovation and in R&D on re-working and recycling of phosphate resources; through its work with farmers around the world and the application of customised fertilisers; and in the development of technologies at its Mohammed VI Polytechnic University. OCP is engaged in efforts to study and develop means to effectively recycle phosphorus after its initial use to reduce the amount of mined phosphate required to produce the same quantity of food. In Africa, OCP has worked with more than one million farmers to educate on the importance of sustainable fertiliser application to maximise yields while preserving the integrity of the soil. OCP Group has developed more than forty customised fertiliser formulas for maximum efficiency and sustainable application, and to explore new technologies and products such as biostimulants and slow release fertilisers, among others, with the objective of an optimal consumption of the phosphate resource. OCP has been a founding member of the North America Sustainable Phosphorus Alliance and has now joined ESPP.

https://www.ocpgroup.ma/fr

EU Fertilising Products Regulation

New proposals for by-products

The European Commission has published its third report towards criteria for using "By-Products" as Component Materials for EU fertilising products (**CMC11, additives and CMC-WW**) **for comment by 16th August 2021**, under the new EU Fertilising Products Regulation 2019/1009). The 180-page document now proposes detailed criteria for which families of by-product would be eligible, with proposed quality/purity criteria, contaminant limits, process input material exclusions, etc. This was discussed at the EU Fertilisers Expert Group 24-25 June, at which ESPP was represented.

The following summarises ESPP's understanding of the JRC proposal.

ESPP welcomes positively that phosphogypsum and other mineral processing by-products are included, and that a new route is opened to include nitrogen salts recovered from biogas or manure or animal housing gas treatment. However, this will probably only cover recovery from sanitised manure, unless data can be produced to show the safety (absence of pathogens) in such materials (see below).

The new proposal is significantly narrower than was suggested in March this year (CMC-WW initial proposal, see ESPP eNews n°53). ESPP's request to widen to "derivates" (see ESPP eNews n°54) has not been taken up, that is the eligible by-products can only be included directly, as such, in an EU fertilising product, that is with no further chemical processing. They cannot be used as a precursor to produce other materials (note that by-products can be used as precursors in CMC1, but not if they have "waste" status).

The new JRC proposal is somewhat complex, with four different routes:

Routes (1) and (2) are subject to the requirements that (a) the material must be a "by-product" as defined under the Waste Framework Directive 2008/98/EC, (b) Animal By-Products, polymers, compost and digestate are excluded, and (c) the material must be REACH registered (with conditions). For routes (1) and (2) a specific list of contaminant limits is defined.

(1) By-products from seven specified industrial processes: methionine, mineral ore processing (this category includes by-product **gypsums and phosphogypsums**), Solvay process, acetylene production, ferrous slags, specific metal treatments, humic/fulvic acids from drinking water treatment;

(2) (any) by-product used as a "technical additive" at <5% total in the final EU fertilising product.

Routes (3) and (4) are "CMC-WW High Purity Materials", which was originally proposed in March this year (see ESPP eNews n°54). This proposal has been significantly narrowed and now covers ONLY mineral salts of ammonia, sulphur (inc. elemental sulphur), calcium carbonate or calcium oxide, subject to 95% purity and organic carbon < 0.5%. These mineral salts must also respect a detailed and extensive limits of contaminant limits, and must be REACH registered (with conditions). They can result from:

(3) any "production" process, to which inputs can be any material (chemicals, biomass …), but NOT waste and NOT Animal By-Products

(4) gas purification from (to simplify): hygienised manure, non-hazardous wastes or any other material except Animal By-Products. The list currently includes livestock housing offgas and gas from on-farm, storage of non-hygienised manure, but these are liable to be deleted]

European Commission JRC "Technical proposals for by-products and high purity materials as component materials for EU Fertilising Products. Interim report", 14 June 2021 https://circabc.europa.eu/ui/group/36ec94c7-575b-44dc-a6e9-4ace02907f2f/library/785d1835-07b3-4b3c-a46a-e269a33c74c7/details
Comments are open to 16th August but can only be submitted via members of the EU Fertilisers Expert Group. Please therefore send all comments to ESPP info@phosphorusplatform.eu before 16th July, in order to enable them to be taken into account.

Slow progress Animal By-Products, progress on other points

At the EU Fertilisers Expert Group, 24-25 June, of which ESPP is a member:

The European Commission DG SANTE summarised slow progress on criteria for using Animal By-Products (ABPs) in EU fertilising products (currently an 'empty box' in CMC10 in the Fertilising Products Regulation 2019/1009 = FPR). Work has not yet started on End-Points for ABPs under the FPR, but that the EFSA opinion is expected on some materials in September 2021 (EFSA mandate 2020-0088, see ESPP eNews n°50). It thus seems inevitable that the End-Point criteria will not be adopted by the date of entry into application of the FPR in July 2022. This is the regrettable consequence of the fact that the mandate to EFSA was only transmitted by DG SANTE to EFSA in May 2020, nearly a year after publication of the FPR and more than four years after publication of the proposed regulation which already included the CMC10 'empty box'.

The Commission presented development of the 'FAQ' which provides guidance on the FPR. New adjustments clarify on additives, contaminants in CMC materials, waste plant materials (CMC2), definitions of 'sludge', blue green algae.

It is confirmed that plant materials with waste status (e.g. garden waste) can be used as input to CMC2 (subject to the processing limits specified) and so achieve End-of-Waste status when integrated into an EU-label fertilising product.

Pyrolysis products and biochars from manure and Animal By-Products: DG SANTE indicated that if companies wish these to be included in the FPR, then they should submit a dossier to EFSA requesting an ABP End-Point. At present, there is no Commission mandate to EFSA to develop an ABP End-Point for pyrolysis, gasification and biochar materials. Until such an ABP End-Point is defined and adopted, biochars from manure or animal by-products will be excluded from EU fertilisers. Companies with data showing pathogen safety of biochars from manure or animal by-products are invited to contact ESPP to develop together a dossier for EFSA.

STRUBIAS criteria moving towards adoption. The European Commission confirmed that the EU Fertilising Products Regulation criteria for precipitated phosphate salts, ash-derived products and biochars/pyrolysis materials (STRUBIAS) are progressing towards Commission adoption, which will be followed by the standard three month 'objection' period, before publication, so should be published significantly before entre into application of the Regulation in July 2022.

ESPP letter to the European Commission on "Animal By Product End Points for EU Fertilising Products Regulation STRUBIAS materials", 16th April 2021 www.phosphorusplatform.eu/regulatory

STRUBIAS criteria, as published for the public consultation February 2021
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12136-Pyrolysis-and-gasification-materials-in-EU-fertilising-products
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12162-Thermal-oxidation-materials-and-derivates-in-EU-fertilising-products
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12163-Precipitated-phosphate-salts-and-derivates-in-EU-fertilising-products

Call for data on pathogens / safety of recovered ammonia / sulphur

The principle of inclusion of ammonia or sulphur materials recovered from gas stripping in EU-fertilisers seems now accepted (CMC-WW) but those from manure may be excluded, unless data is available on pathogen levels and safety. Nitrogen and sulphur materials recovered from gas cleaning in anaerobic digesters, sewage works, waste incinerators or other installations look likely to be included in the new CMC-WW of the EU Fertilising Product Regulation (see above). However, recovery from (non-sanitised) manure, manure digestion, livestock stables or other animal by-products will likely be excluded unless data is provided to show absence of pathogens and hygiene safety. It seems probable that the transfer via the gas phase, then acid stripping and concentration in mineral solutions, prevents or eliminates pathogens, but to date very little data has been provided to the Commission. Data will also support an ongoing ESPP request to exonerate such recovered materials from the Animal Feed regulation clause which currently prevents placing them on the market as commodity chemicals. Possibly also, a request to EFSA should be prepared to develop and Animal By-Product End-Point for such recovery processes.

If you have such data, or are willing to cooperate in developing such data (analysis of recovered nitrogen or sulphur materials), please contact ESPP.

EU tender for study on fertiliser and mulch polymer biodegradability

The European Commission has opened to 31st August a tender to assess biodegradability criteria for polymers used in fertilisers (coating agents, water retention, wettability) or in mulch films. Value: up to 300 000 €.

Submission deadline 31st August 2021. TED (EU tender website) Services 311603-2021 link.

Policy

European Commission takes Member States to court over sewage treatment

Belgium, France, Greece, Hungary and Spain face European Court of Justice action over inadequate collection and treatment of municipal wastewater.

The European Commission has referred **France** to the European Court of Justice (ECJ) for failure to adequately treat sewage of more than 100 agglomerations (non-compliance with the 1991 Urban Waste Water Treatment Directive 91/271/EEC, which should have been fully implemented by 2005). Fifteen of these French agglomerations also fail to meet additional treatment requirements in eutrophication Sensitive Areas (phosphorus removal).

The Commission is also referring **Hungary** to the ECJ because 22 agglomerations are not collecting all residents' sewage, relying instead partly on individual treatment systems (septic tanks), which are considered to not provide adequate treatment.

The Commission has issued a Reasoned Opinion to **Belgium** for non-compliance of 11 agglomerations: this gives the Member State two months to reply and take necessary measures, or face referral to the (ECJ).

The Commission has issued a Reasoned Opinion to **Spain** concerning over 300 agglomerations which do not treat sewage adequately, and a further 30 agglomerations where sewage is not collected and treated centrally, instead relying on individual treatment systems.

European Commission "June infringements package: key decisions", Brussels, 9 June 2021
https://ec.europa.eu/commission/presscorner/detail/en/inf_21_2743
"Urban Waste Water: Commission decides to refer FRANCE to the Court of Justice over waste water treatment", 9 June 2021
https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1546

SYSTEMIC policy proposals to open markets for recycled nitrogen

The EU-funded project SYSTEMIC has presented for discussion proposals for EU policies to enable nutrient recovery to economic, in particular by bringing recycled nitrogen fertilisers into the EU Emissions Trading System. SYSTEMIC proposes to open carbon credits for biogas plant operators not only for bio-methane but also, if nitrogen is recovered and recycled, for avoided carbon emissions for production of equivalent mineral nitrogen fertilisers. It is proposed also to open carbon credits for farmers using recycled N fertilisers and for fertiliser companies who include recycled N into their products. These proposals are based on LCA data which suggests a benefit of 3 tCO_2-eq per tonne N comparing recycled N fertilisers[1] (assumed zero CO_2 emissions, as using energy from waste biogas) to mineral fertilisers[1]. As proposed by SYSTEMIC, however, such carbon credits could penalise farmers who use manure on-farm and benefit large-scale livestock production, in that SYSTEMIC combines the carbon credit proposal with support for the JRC 'RENURE' concept which is considered by some as an attempt to facilitate intensive livestock production (see ESPP eNews n°47). It should be ensured that small and extensive farms can be equally rewarded for appropriate manure management. The carbon credit base is not applicable to recycled phosphorus, but could perhaps be transposed into a Nutrient Emissions Trading System with phosphorus credits.

1: EU average CO_2-eq. per tonne N, from Hoxha & Christersen, IFS Proceedings 805, 2018
SYSTEMIC is an EU Horizon 2020 project and an ESPP member. SYSTEMIC webinar ""Enabling the Circular Economy: How to encourage a viable agricultural market for nutrients recovered from biowaste", 13 June 2021. Watch here.

Legacy Phosphorus

Frontiers in Earth Science special on 'Legacy Phosphorus'

This journal issue includes 11 papers addressing phosphorus use in fertilisers and in soils. Six of these which include data relevant to discussions of 'Legacy Phosphorus' are summarised below. The other papers concern modelling, biostimulant bacteria, use of paper mill biosolids or sewage sludge. The editorial of this journal (Gatiboni et al.) suggests that the two Zhang et al. studies show that soil "Legacy Phosphorus" can be reduced without deteriorating crop productivity, whereas this is only demonstrated in a situation where initial soil P is higher than recommended, and that cropping with fertilisation can increase legacy P, whereas this is only shown in the scenario of P-fertilising grassland but not harvesting the grass (this could occur for example in grass buffer strips receiving P from runoff/erosion). The editorial also suggests that de Souza Nunes et al. shows that fertiliser application tends to accumulate legacy P: this is also misleading in that this study started with initially "very low" soil P where increasing the soil P was necessary for productive agriculture.

The editorial does not mention several conclusions which can be suggested from the six papers summarised above:

- If soil P is above agronomic recommended levels, application of P fertiliser will probably not increase yield, but if soil P is low, then P-fertiliser is needed or significantly lower crop yields will result;
- Soluble mineral P-fertiliser gives better fertiliser results, and leads to less accumulation of P in soil, than (reactive) rock phosphate application;
- Soil P levels low enough to ensure environmental objectives may be lower than agronomic optimal, and so result in losses of crop productivity.

In correspondence with the editors, it was noted that this discussion contributes to debate, and underlines the conundrum of sustainable production: how to balance maximising yield against protecting the environment. Lower phosphate inputs and reduction of soil P levels, possibly below agronomic optimum levels, may be necessary to achieve environmental objectives, but will reduce productivity, maybe considerably (see eg. McDowell et al. below), with impacts for both food production and farmers' incomes.

"Legacy Phosphorus in Agriculture: Role of Past Management and Perspectives for the Future", 143 pagers in total, ed. L. Gatiboni et al., Frontiers in Environmental Science, January 2021, Legacy Phosphorus in Agriculture https://www.frontiersin.org/research-topics/10116/legacy-phosphorus-in-agriculture-role-of-past-management-and-perspectives-for-the-future#articles

Soil P above agronomic recommendations does not increase yield

Zhang et al. report data from 11 years' field trials comparing P-fertiliser application to zero-P application in Ontario, Canada (Lake Erie catchment). Within the field, randomised plots of 0.1 ha each were given P fertiliser (50 kgP/ha once every two years), plus N+K, or only N+K, in soy /maize rotations, with fertilisers only in the maize years. Surprisingly given the random plot allocation, the soil Olsen P was initially considerably higher in the plots not receiving fertiliser (c. 60 mg/kg Olsen P in the top 15 cm of soil, versus c. 40 in the P-fertilised plots). 30 mg/kg is the agronomic recommended Olsen P level for maize and soybean. The soil Olsen P was nearly the same in the P-fertilised and unfertilised plots after 11 years, at the end of the trials, because it remained approximately constant in the P-fertilised plots but fell in the unfertilised plots. Crop productivity and crop P-offtake were similar in P-fertilised and unfertilised plots. The authors calculate that in the unfertilised plots net P-removal in crops was around 18 kgP/ha/year, so that in the P-fertilised net P-balance would be around +7 kgP/ha/y. Despite this, soil Olsen P did not measurably increase in these plots over the 11 years.

This study shows that soil Olsen P levels higher than agronomic recommendations do not lead to increased crop productivity. While the study is to continue, it is too early to inform as to whether or not crop productivity will be lost if soil P levels are "drawn down" below agronomic recommended levels.

"An 11-Year Agronomic, Economic, and Phosphorus Loss Potential Evaluation of Legacy Phosphorus Utilization in a Clay Loam Soil of the Lake Erie Basin", T. Zhang et al., Front. Earth Sci. 8:115 https://dx.doi.org/10.3389/feart.2020.00115

45 years of P fertilisation does not increase total soil P

Zhang et al. assess data from long-term field trials, Ontario, Canada, comparing different soil P fractions after 45 years of NPK phosphorus fertilisation to no fertilisation (no P, no N, no K), under three different tile-drained cropping systems: harvested maize, harvested oats-alfalfa rotation or permanent (i.e. not annually ploughed), unharvested grass, comparing also to non-cropped, non drained woodland. The fertilised fields received NPK fertiliser with 29 kgP/ha/year. A previous study suggested that c. 1.5 kgP/ha/y is lost in tile drains. The fertiliser application, after 45 years, resulted in no significant increase in total soil P in the two harvested crops (compared to the woodland soil) but an increase in the fertilised, non-harvested grassland (this is not representative of real farm operation where fertilised grass is harvested and removed, resulting in P-offtake). All the cropped fields without fertilisation, including to a lesser extent the grassland, showed significantly lower total soil P after 45 years. Changes in the different solubility fractions of organic and inorganic fractions of P in the soils are assessed, showing that the rate of mineralisation of organic P is increased with cropping + drainage, with or without NPK fertilisation.

"Legacy Phosphorus After 45 Years With Consistent Cropping Systems and Fertilization Compared to Native Soils", T. Zhang et al., Soils. Front. Earth Sci. 8:183 https://dx.doi.org/10.3389/feart.2020.00183

Focusing only on decreasing soil P will take 26-65 years to reach environmental P targets

McDowell et al. analysed c. 4.5 million data points for Olsen P from two soil sample databases (Eurofins + Hills Labs, ARL) from commercial farms in New Zealand 2001-2015. Nearly half of these were for dairy, a further third for sheep and beef, <25% cropland and some horticulture. Nearly two thirds of samples showed Olsen P higher than agronomic recommendations. Modelling suggested that not applying P fertilisers would result in a fall in Olsen P to agronomic recommended levels in less than one year. This would not however correspond to environmental objectives, and reducing P-losses in drainage and runoff water to 0.02 mgP/l would require soil P levels significantly lower than agronomic recommendations. It would take 26-55 years for soils to reach environmental targets and the cessation of fertiliser inputs would likely result in large losses in agricultural productivity (these losses are not estimated).

"The Ability to Reduce Soil Legacy Phosphorus at a Country Scale", R. McDowell et al., Front. Environ. Sci. 8:6 https://dx.doi.org/10.3389/fenvs.2020.00006

Initial soil P level defines maize productivity

Messiga et al. report results of a total of eleven 1-year silage maize field trials at 3 sites in 2018 and 8 in 2019 in BC, Canada, each with six treatments x 4 replicates on 45 m^2 plots: five treatments with a total of 35 kg available-P/ha (of which 0 – 20 from TSP [triple super phosphate] and the remainder from liquid dairy manure) and one control (zero P). 35% of manure P was estimated to be "available". The TSP fertiliser was band applied immediately after seeding the maize whereas the manure was applied at the 6-leaf stage. Additional N was applied as ammonium nitrate at the 6-leaf stage to meet the local recommendation of 150 kg N/ha. Generally, dry matter yield (DMY) at harvest was not higher in the plots with added P (be it as starter fertiliser or as manure at the 6-leaf stage) compared to the zero-P plots (fig. 4). At four sites, DMY did increase with P, showing optimum with low starter fertiliser and most P input from manure. Maize initial growth was improved by the starter fertiliser application, but this did not carry through to harvest. DMY at harvest did however vary strongly with initial soil phosphorus index, from 15 t/ha DMY in sites with low initial soil P (Mehlich-3 60 mgP/kg) to nearly the double (27 t/ha DMY) at sites with high initial soil P (Mehlich-3 200 mgP/kg). The authors note that the soil PSI (Phosphorus Saturation Index, an agro-environmental indicator), a proxy for DPS (Degree of P Saturation), is correlated to DMY, so may be a good indicator for adjusting P application. Overall, the trial results seem to suggest that initial soil P (that is, legacy P) generally influences maize productivity much more than P application in the year.

"Combined Starter Phosphorus and Manure Applications on Silage Corn Yield and Phosphorus Uptake in Southern BC", A. Messiga et al., Front. Earth Sci. 8:88, https://dx.doi.org/10.3389/feart.2020.00088

Mineral fertiliser offers better P-balance than phosphate rock

Soltangheisi et al. report results of nine years of field trials (25 m2 plots) in South Brazil, no-till cultivating each year maize and a winter cover crop. 3x6 treatments were trialled: no-P, single super phosphate mineral fertiliser (SSP, 46-59 kgP/ha) or Algerian rock phosphate (148-190 kgP/ha), but in all cases with no-P for the last two years x 5 different winter cover crops or no cover crop (fallow). The soil at the start of the nine years was considered to have low P in the top 0 – 10 cm and very low P at 10 – 20 cm depth, despite commercial no-till cultivation for the years prior to the trials. P-fractions in soil were analysed at 0-5, 5-10 and 10-15 cm depth. Cover crops showed to bring P up from the soil, accumulating organic P on the soil surface. Considerably higher P-efficiency (total over the nine years, as P in harvested grain / P inputs) was shown with SSP (39 – 55%) compared to rock phosphate (15 – 27%). With SSP, the P-efficiency with some cover crops was higher than fallow (48%), but was similar or lower with others. Total maize grain yield was around one third higher when P fertiliser was applied than with no-P, but was similar between SSP and rock phosphate (as tested, that is with 3 – 4 x more total P input with rock phosphate) and for the different cover crops or fallow.

"Cover Cropping May Alter Legacy Phosphorus Dynamics Under Long-Term Fertilizer Addition", A. Soltangheisi et al., Front. Environ. Sci. 8:13 https://dx.doi.org/10.3389/fenvs.2020.00013 and "Do cover crops change the lability of phosphorus in a clayey subtropical soil under different phosphate fertilizers?", A. Teles et al., Soil Use and Management, March 2017, 33, 34–44 https://dx.doi.org/0.1111/sum.12327

Mineral fertiliser offers better crop yield than phosphate rock

De Souza Nunes et al. report results of seventeen years of field trials in Brazil, 32 m2 plots, with 8 treatments: conventional or no-till x broadcast or furrow fertiliser application x TSP (triple super phosphate) or reactive rock phosphate (both at 35 kgP/ha/y). This reactive rock phosphate had high carbonate content, and so high P availability (44% citric acid solubility of P). Soybean and corn were cultivated. The soil initially had very low P availability and c. 1 mgP-total/kg. Results showed that broadcast fertiliser application resulted in a higher grain yield than furrow fertiliser placement. Under no-till, TSP resulted in grain yield c. 10% higher than with reactive rock phosphate, irrespective of spreading method. Under conventional tillage, TSP gave marginally higher (1-2%) yield than reactive rock phosphate for comparable spreading method. Reactive phosphate rock generally, but not consistently, led to higher accumulation of phosphorus in soil, especially calcium-associated phosphorus and particularly when broadcast.

"Distribution of Soil Phosphorus Fractions as a Function of Long-Term Soil Tillage and Phosphate Fertilization Management", R. de Souza Front. Earth Sci. 8:350 https://dx.doi.org/10.3389/feart.2020.00350

IFA Smart&Green

This online event showcased 26 crop nutrition start-ups and discussed innovation from technology to market for new fertiliser approaches: biostimulants, controlled release, organic fertilisers, nutrient recycling and data solutions. This was IFA's (International Fertilizer Association) first innovation conference and attracted over 400 registrants (220 online participants for the recycling session).

Chris Thornton, ESPP presented an overview of EU policies driving nutrient recycling and of different routes, from agricultural valorisation of sewage biosolids or processed digestate, through use of wastewater nutrients to feed biomass, to technical recovery of phosphate chemicals from ashes and other waste streams (ESPP slideshare).

Nutrient recycling

Yariv Cohen, EasyMining (RagnSells), presented the Ash2Phos process for recovery of high purity PCP (precipitated calcium phosphate) from sewage sludge incineration ash. Two full scale sites are under permitting: Helsingborg, Sweden and Gelsenwasser, Germany (both 30 000 t-ash/year, that is each around 3.5 million population wastewater), see ESPP eNews n°55. EasyMining's objective is to be processing 300 000 t-ash/year by 2030.

Joseph Dahan, SGTech, presented their three-stage anaerobic/aerobic digestion system for manures, in which the third biological stage transfers over 60% of the phosphorus into the solid fraction (in particular as polyphosphate). Overall, methane production is increased (+25% compared to standard AD is claimed) and 80% nitrogen removal is achieved (released as N_2 not as ammonia because of neutral pH operation). A pilot plant is in operation since 2018 (c. 15 000 t/y of manure from 100 cattle) and several further projects are currently in planning, both using containerised installations for smaller farms (< 200 cattle) and a possible project to treat pig manure.

Thomas Mannheim, Ductor, presented the company's technology for anaerobic digestion of nitrogen-rich substrates like poultry or fish waste, which uses specifically selected bacteria to convert c. 60% of nitrogen to ammonia in a separate digester, upstream of the main anaerobic digester. All nutrients are converted to fertilisers: ammonia is stripped and recovered as a liquid nitrogen fertiliser, and the digestate from biomethane production is used for the production of organic NPK fertilizers. A first full scale plant (poultry litter) is operating at Juanita, Mexico, since January 2020 (0.25 MW electrical capacity) and a second one starts in June 2021 in Germany (0.5 MW). Further projects are under planning in Poland, the USA and Norway (up to 4 MW). The technology is modular, scalable, can be added to existing biogas plants or in new plants.

Organic fertilisers

Chiara Manoli, ILSA and ECOFI, summarised innovation and R&D in processed organic fertilisers. The EU market is at present around 3 million €/year and growing c. 4%/year. Organic fertilisers offer agronomic benefits including nutrient release rates adapted to plant needs, higher phosphorus uptake, and interactions between nutrients and humic substances which protect nutrients in soil from losses and stimulate soil microbial activity (see SOFIE conference summary in ESPP SCOPE Newsletter n°130). Innovation and research is today orientated to enable use of varied organic secondary materials as inputs whilst ensuring traceability, safety and predicable product quality; production technologies to improve quality and nutrient content; customised formulations for specific crops or soils; improving understanding of nutrient mineralisation, impacts on soil microbial activity and agronomic effectiveness; combinations with mineral nutrients (organo-mineral formulations) and information of farmers.

David Lebret, Innovafeed, introduced the agronomic and environmental benefits of insect frass as an organic fertiliser. Innovafeed operates two insect farms in northern France, upcycling wheat by-products to rear black soldier fly larvae, generating proteins and oil for animal nutrition as well as insect frass (a mixture of insect faeces and used substrate) for plant nutrition: Gouzeaucourt (pilot scale, capacity 1.000T/yr protein & 6.000T/yr raw frass) and Nesle (industrial scale, 15.000T/yr protein & 50.000T/yr processed frass). Insect frass both supports plant growth (thanks to a combination of N, P and K nutrients, both rapidly and more slowly available) and stimulates soil activity (high concentration in organic matter content and presence of beneficial bacteria and chitin with biostimulation effects). See IPIFF position in ESPP eNews n°40.

Hugh MacGillivray, Anuvia, presented the company's innovative organo-mineral fertiliser, made by fixing mineral N, S and P to amino acids using inputs such as food waste, manure, agricultural by-products and wastewater residuals. A pilot production plant has now been operating for five years (???? t/y) and a 1.2 million t/y plant is now under construction in partnership with Mosaic. The product offers controlled nutrient release: 70% N in 2-3 weeks and the remaining 30% in the following two months. Over 350 field trials show an average +5% yield compared to mineral fertilisers, and studies suggest also lower nutrient losses, plant nutrition stable over time and lower overall greenhouse emissions (-10%).

Innovation and research

Michael McLaughlin, University of Adelaide, outlined the very wide range of innovations in fertiliser technologies, both for products, in patents and research publication. These include: delivering mineral fertilisers as nanomaterials, layered double hydroxides, graphene-based materials, hydrogels, zeolites, stabilised N fertilisers, sulphur-polymer composites, metal-organic molecules, microbes and biostimulants.

Phil Pardey, University of Minnesota, summarised data since the 1970's on global agricultural R&D spending. Developed countries have a considerably reduced share of global public spending on agriculture R&D which became particularly pronounced after 2000. Many high-income countries have also reorientated research away from productivity, e.g. towards sustainability. The share of global agricultural R&D spending by low-income countries has also shrunk, but there is substantial growth in Asia and Brazil. Agriculture R&D is increasingly privately funded and performed. Nearly ¾ of total agriculture R&D spending occurs in just 10 countries, with China accounting for over ¼ of the global total.

Biostimulants

Patrick Brown, UC-Davis, suggested that biostimulants all function by helping plants to deal with stress (i.e. increase crop system resilience), for example water stress or nutrient limitations. Environmental stress of crops is ubiquitous, so the potential value of biostimulants is significant. There are however major challenges for R&D, product development and testing, in that biostimulant effect will be related to occurrence of stress, which is unpredictable and often different stresses occur at the same time. Precision agriculture can however improve this targeting.

Manish Raizada, University of Guelph, Canada, showed that microbial biostimulants can have a range of functions, including solubilising minerals in soil such as P, K, Zn, Si so making them plant available, promoting root growth so improving fertiliser uptake, improving yield by promoting growth, combating plant pathogenic microbes. In particular, he presented developments in nitrogen fixing microbes: recent work has shown that repeated rhizobia inoculation through the growing season can increase yields of soy (a legume, which "naturally" has such nitrogen-fixing microbes), and combining rhizobia with other specific bacteria or fungi can also increase yields. There are many nitrogen-fixing rhizobia microbe products on the market.

Luca Bonini, Hello Nature, presented some crop benefits shown for the company's peptide biostimulant. In spinach, yield was increased +8% (with nitrogen fertiliser) to +33% (no N fertiliser): the peptides are thought to act as signalling molecules, inducing nutrient uptake by the plant. In lettuce, the peptides showed to reduce yield loss caused by salinity: that is, mitigate plant stress. A biostimulant containing micro-organisms and root-stimulating peptides showed to increase both weight yield and sugar contents in melons. He underlined the need for more research and innovation into biostimulants, tailor-made to specific needs, and for field trials with different crops in different conditions, in order to provide appropriate information to farmers.

Andrea Bagnolini, Salvi Vivai (Italy's leading fruit tree nursery), indicated that there are three types of biostimulants most used on fruit farms: to improve nutrient uptake, without increasing the use of fertilisers and respecting regulation whilst improving yield (this helped Salvi Vivai to grow the Guinness Book of Records biggest cherry in the world in 2020); to improve crop stress resilience; and to ensure uniform size of fruit, which is important for market value.

Research and science

Will atmospheric P deposition significantly impact peat bog carbon storage?

Mid-latitude peatlands are estimated to hold 0.23 Gt of phosphorus (1.7% of global soil P). A study of 23 such bogs worldwide suggests that increased atmospheric P deposition increases decomposition and reduces carbon fixation. From literature, data on P, N and C in ombrotrophic* peatlands at different depths was identified for 23 sites worldwide, with time accumulation data available for 11 of these (using radioactive dating). This data was combined with rates of P, N and C accumulation in the acrotelm** and catotelm** from a bog in Sweden. Atmospheric P deposition is the limiting nutrient for such peat bogs, limiting productivity and nitrogen fixation in the upper layers, but also limiting decomposition in the lower layers. P:N ratio in accumulated organic material in the catotelm (lower layers) is thus significantly lower than that in the acrotelm (upper layers), as P is recycled in the acrotelm. The field data show a strong positive correlation between phosphorus accumulation in the catotelm and decomposition of organic carbon, and a negative correlation between the catotelm P:N ratio and carbon burial. The authors conclude that although increased P input to such peat bogs will increase primary carbon fixation, the overall impact will be a significant reduction in the carbon burial rate, or possibly even net carbon loss. Questions are therefore raised about how much atmospheric P deposition has increased with anthropogenic activity (e.g. burning fossil fuels) compared to natural sources (desert dust, pollen …) – see ESP eNews n°43. The authors note that deposition to peat bogs will vary considerably with local sources depending on nearby soils and vegetation (dust, pollen). Further work is needed to better understand potential carbon impacts of P deposition to peat bogs at local and global scales.

* *ombrotroph*ic (from Greek: cloud fed) = receiving water and nutrients only from rain, not runoff.
** acrotelm = living and catotelm = dead layers of a peat bog, the catotelm generally being the deeper layer or below the water table, where oxygen *is not available.*
"Phosphorus supply controls the long-term functioning of mid-latitude ombrotrophic peatlands", EarthArXiv pre-review preprint 2021, D. Schillereff et al., DOI.

Field trials of animal bone char as fertiliser

Five year field tests were carried out to compare animal bone char, sulphur-modified animal bone char, triple super phosphate (TSP) and control (no P fertilisers), on soils with three different initial levels of phosphorus. The bone char was purchased from Bonechar Carvao Ativado do Brasil https://www.bonechar.com.br/ and is produced by pyrolysis of animal bones at >800°C, resulting in a material with c. 12% carbon and 70 – 75 % hydroxyapatite (calcium phosphate) content, marketed since 1987 as an activated charcoal material for applications in the food industry, waste treatment, decontamination. The sulphur-modified animal bone char is treated with reduced sulphur gas compounds, e.g. H_2S, according to a 2021 patent application. The field trials were carried out in Braunschweig, Lower Saxony, Germany, with a crop rotation of winter barley, winter oilseed rape, winter wheat, lupin and winter rye. In the first year, on P deficient soil, the control (zero P fertiliser) gave 90% yield compared to TSP, bone char 94%, sulphur bone char 95%. Similar significant differences in yield showed in years 3 and 4, and no significant differences between fertiliser treatments in years 2 and 5.

A second paper analyses the changes in soil bacteria related to P turnover in the field trial soils. Effects of fertilisation with animal bone char and sulphur-modified animal bone char were compared (for soils with very low, low and optimal initial P concentrations) to no P fertilisation (control) and to conventional TSP under winter wheat. Sulphur-enriched bone char addition increased the P-solubilisation potential of soil bacteria. Low soil P concentration and bone char fertilisation favoured P recycling from biomass and bacteria P-uptake systems, indicated by high abundance of bacteria with *pho*D or *pst*S genes. Bacterial P turnover was influenced by the sulphur-enriched bone char, by the plant development stage and by the initial P concentration.

"Agronomic evaluation of bone char as phosphorus fertiliser after five years of consecutive application", K. Panten, P. Leinweber, Journal für Kulturpflanzen, 72 (12). S. 561–576, 2020, ISSN 1867-0911, DOI
"Effects of different innovative bone char based P fertilizers on bacteria catalyzing P turnover in agricultural soils", Agriculture, Ecosystems and Environment 314 (2021) 107419, DOI.

Pyrolysis reduces availability of phosphorus in poultry manure

Granulated poultry manure showed the same P fertiliser efficiency as superphosphate, but was less than half as effective after pyrolysis. **N fertiliser efficiency was reduced by more than 90% after pyrolysis.** Fertiliser efficiency was tested in five-month pot trials with rye grass in low-P soil, pH 6.5. Poultry manure (bedded with Sphagnum peat) was tested after granulation to 3 – 6 mm (from Biolan), after mixing with feather meal and after pyrolysis at 460°C for 90 minutes. Yield-based fertiliser efficiency was compared to mineral phosphate fertiliser (superphosphate). The granulated poultry manure showed the same P-efficiency as superphosphate (100%) over one growing season, the mixture with feather meal somewhat lower efficiency (75%) and the pyrolysed poultry manure much lower P-efficiency (45%). Soil inoculation with arbuscular mycorrhizal fungi (AMF) did not enhance the P-efficiency. In a previous paper, the N fertiliser efficiency of the pyrolysed poultry manure showed (in the same pot trials) to be only 3% that of mineral N fertiliser, compared to 45 – 50% for granulated manure.

"Bioavailability of phosphorus in granulated and pyrolyzed broiler manure", M. Sarvi et al., Environmental Technology & Innovation 23 (2021) 101584 DOI. "Granulated broiler manure based organic fertilizers as sources of plant available nitrogen", R. Keskinen et al., Environmental Technology & Innovation 18 (2020) 100734 DOI.

Struvite effective fertiliser with lower P-loss risk

Pot trials with maize and soy conclude that blending 25% - 50% struvite with mineral P fertiliser reduces P-loss risk without restricting early-season growth. Soil pH was 5.6. Struvite (Ostara) was granule size 1.5 – 3 mm and mineral P fertiliser was MAP (mono ammonium phosphate) granule size 3 mm. Maize and soybean biomass was measured after 44-45 days. Maize showed the same biomass production with 25% or 50% struvite compared to 100% MAP. Soy showed the same biomass production with 25% struvite. Results for P-uptake were, however, very different. P-uptake was the same for up to 100% struvite with maize, but was higher with struvite than with MAP for soy . Residual soil Mehlich-3 phosphorus decreased with increasing % of struvite used, suggesting lower risks of P-losses to surface waters.

"Maize and soybean response to phosphorus fertilization with blends of struvite and monoammonium phosphate", A. Hertzberger et al., Plant Soil 2021 DOI.

Global Phosphorus Institute launched

The new institute, GPI, launched by the Mohammed VI Polytechnic University, Morocco, aims to promote global, science based research and innovation and collaboration on industrial phosphorus use and nutrient stewardship. It will be led by Amit Roy, previously with IFDC and Global Traps, and has an Advisory Board chaired by the President of the Mohammed VI Polytechnic University and including representatives of the Morocco Ministry of Agriculture, the US Sustainable Phosphorus Alliance, industry experts and scientists. The GPI aims to bring together leading scientists, industry, policy makers and stakeholders, to develop inclusive dialogue and collaboration, and to create and share innovative solutions to balance the need and use of phosphorus in the production of health food, animal feed and natural fibres, in the spirit of the UN Agenda for Sustainable Development. *www.tgpi.org*

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