Opportunities and challenges of meeting crop and soil nutrient requirements using bio-based fertilisers

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@ForrestalPJ

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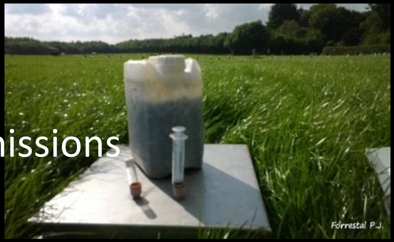
Soil & Plant Nutrition team

My team on

- conventional & new mineral fertilisers
- New bio-based recycled fertilisers from the bio-economy
- Organic manures
- On-going N,P,K,S & inhibitor work
- National, EU & industry funded projects

Agronomy – Water & Air losses – Soil Health integrated

e.g.
Lysimeters
Gaseous emissions



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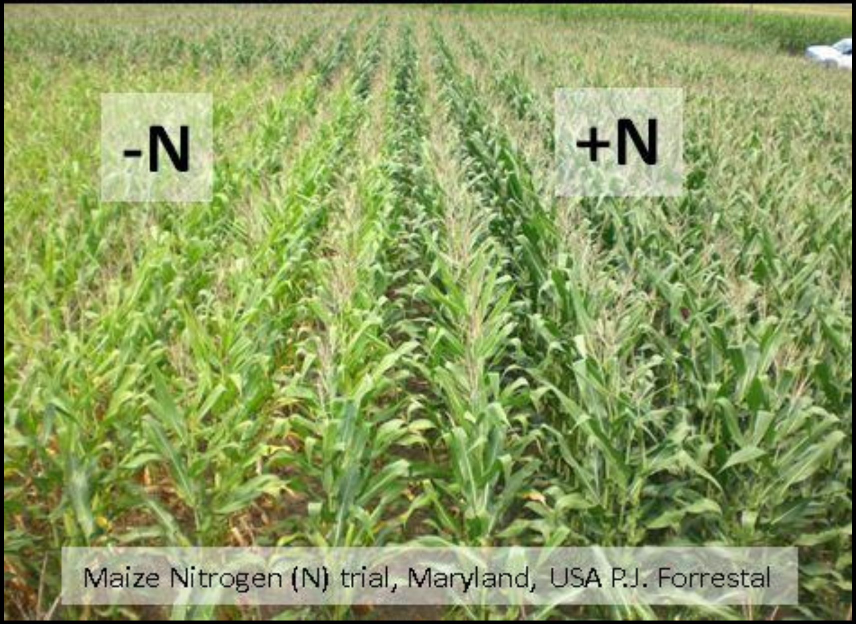
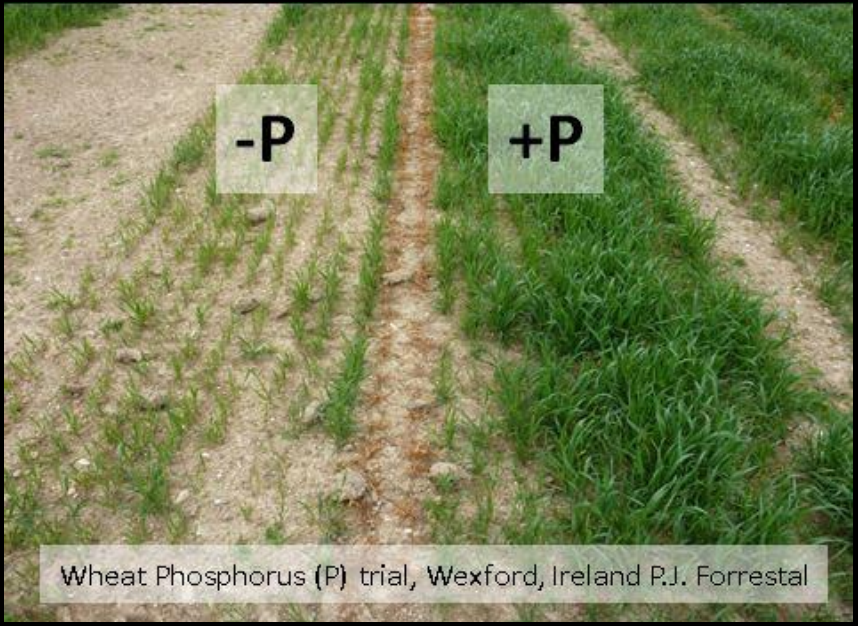
Running down soil fertility





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Nutrient recycling role bio-based fertilisers
Opportunities and Challenges

https://ec.europa.eu/eip/agriculture/en/focus-groups/nutrient-recycling

- EIP-Agri Focus Group Work
- In 2016 selected along with 20 experts (Scientists, Farmers, Advisors & Industry) from 16 countries to assess and report on:
- How to improve the agronomic use of recycled nutrients (N and P) from livestock manure and other organic sources?

Results

- Starting paper
- Final report
- Factsheet

Other information

- Agenda 1st meeting, 31 May - 1 June 2016. Svartsjö - Stockholm, Sweden
- Agenda 2nd meeting, 15-16 November 2016. Leuven, Belgium
- Mini-paper 1: Available technologies for nutrients recovery from animal manure and digestates
- Mini-paper 2: On Farm Tools for accurate fertilisation
- Mini-paper 3: On Farm Practices
- Mini-paper 4: Towards increasing the mineral fertiliser replacement value of biobased fertilisers
- Mini-paper 5: The value of recycling organic matter to soils: Classification as organic fertiliser or organic soil improver
- Mini-paper 6: End-user requirements for recycled and biobased fertiliser products
- Mini-paper 7: Regulatory environment effecting nutrient recycling
- Mini-paper 8: Assessing the environmental effects of nutrient recycling from organic materials used as fertilisers

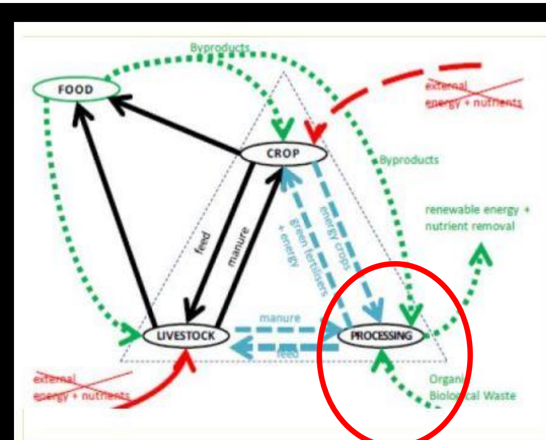

Figure 1. Agro-processing of residues could serve to reconnect nutrient cycles between plant and animal production

Where does conventional mineral P fertiliser come from?

Mosaic Phosphate mine, Florida, USA

Is there a need for recycling and reuse of P in Ireland?

An overview on deficit and requirements of the Irish national soil phosphorus balance

https://www.sciencedirect.com/science/article/pii/S0048969721023226?via%3Dihub

Check for updates

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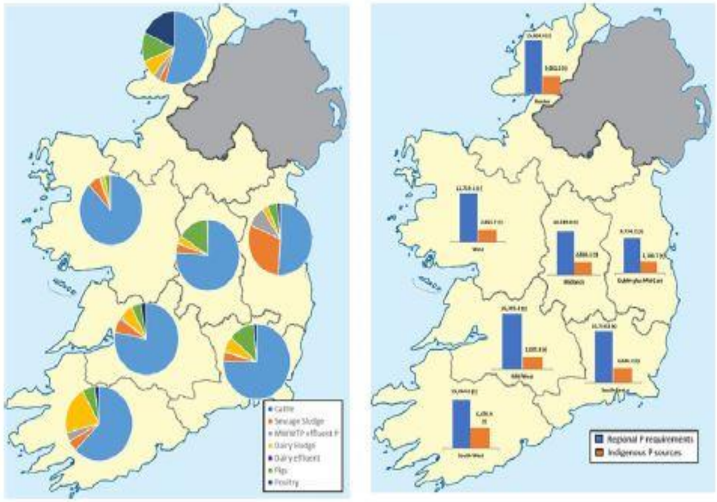
HIGHLIGHTS

- 62.8% of Irish agricultural land has agronomically suboptimal P levels.
- 43,000 t of imported P fertilisers are annually applied to Irish agricultural land.
- 95,500 t of P are required annually to sustain crop production and build soil P.
- Cattle produce the largest quantity of indigenous P annually at 19,300 t.
- Ireland produces 30% of its P requirements from indigenous sources.

GRAPHICAL ABSTRACT



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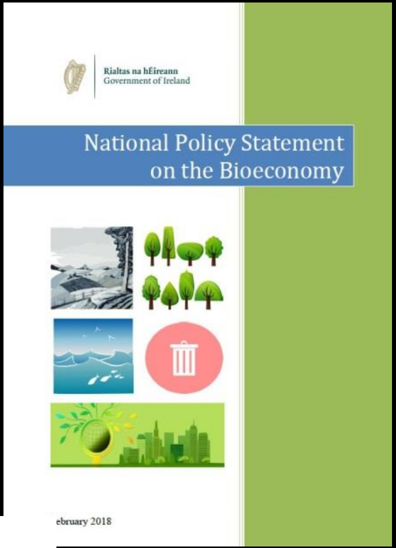
Nutrients: bio-based and mineral – what opportunities do the National (Ireland) and EU Stratagy Statements indicate?

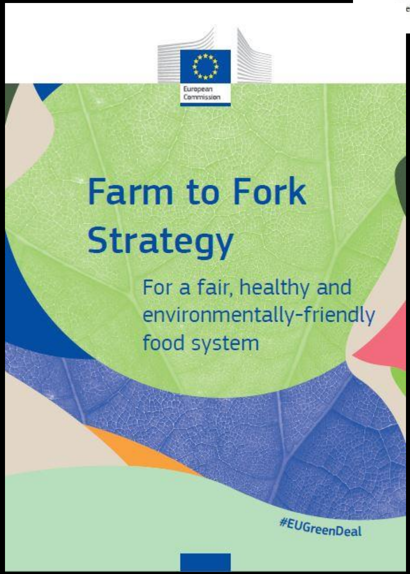
National Policy Statement on the Bioeconomy 2018

- Emphasizes the importance the bioeconomy and using an increasing list of renewable biological resources and in some cases those what would have hitherto been discarded as residues or waste and putting them to more productive uses. It extends across sectors including farming and the agri-food businesses



European Union Farm to Fork Strategy 2020

- The circular bio-based economy is still a largely untapped potential for farmers and their cooperatives. For example, advanced bio-refineries that produce **bio-fertilisers**
- This will **reduce the use of fertilisers by at least 20% by 2030**
- Notably in hotspot areas of intensive livestock farming and of **recycling of organic waste into renewable fertilisers**
- The Commission will act to reduce nutrient losses by at least 50%, while ensuring that there is **no deterioration in soil fertility**



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Nutrients and Soil Fertility Explaining the Irish Systems

of expressing fertiliser nutrient content & soil P & K index system

In Ireland we express & label nutrient content on an Elemental basis i.e. N,P,K,S

Multiply P by 2.29 to convert to P_2O_5

Multiply K by 1.21 to convert to K_2O

Multiply S by 2.5 to convert to SO_3

Soil Index System

Morgan's extract used

Soil Index	Index description	Response to fertilizers
1	Very low	Definite
2	Low	Likely
3	Medium / Adequate	Unlikely / Tenuous
4	Sufficient / High	None

Table 4-4: The P Index system

Soil P Index	Soil P ranges (mg/l)	
	Grassland crops	Other crops
1	0.0 – 3.0	0.0 – 3.0
2	3.1 – 5.0	3.1 – 6.0
3	5.1 – 8.0	6.1 – 10.0
4	Above 8.0	Above 10.0

Table 4-5: The K Index system

Soil K Index	Soil K ranges (mg/l)
1	0 – 50
2	51 – 100
3	101 – 150
4	Above 150

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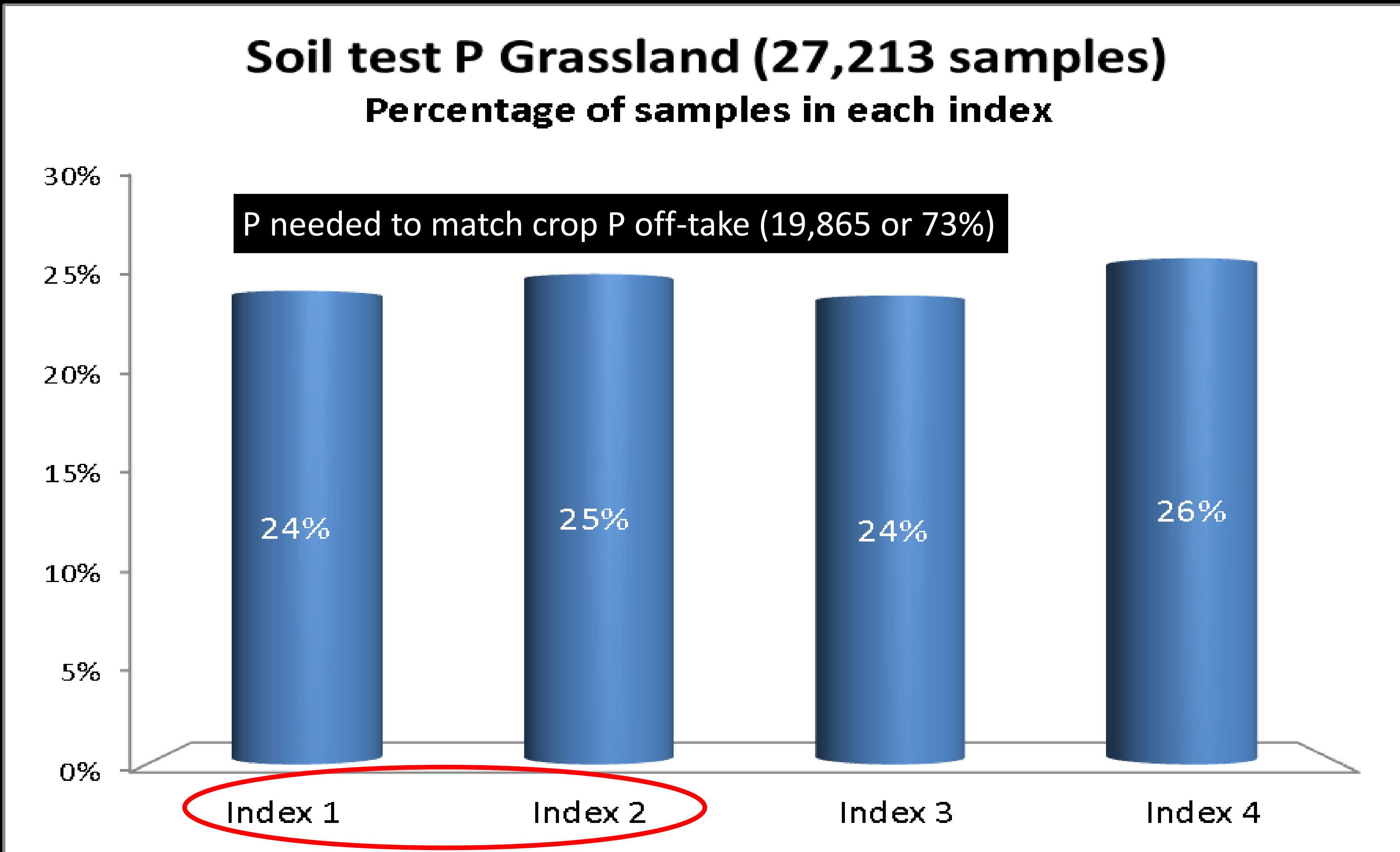
Irish Grassland soils 2019 - P



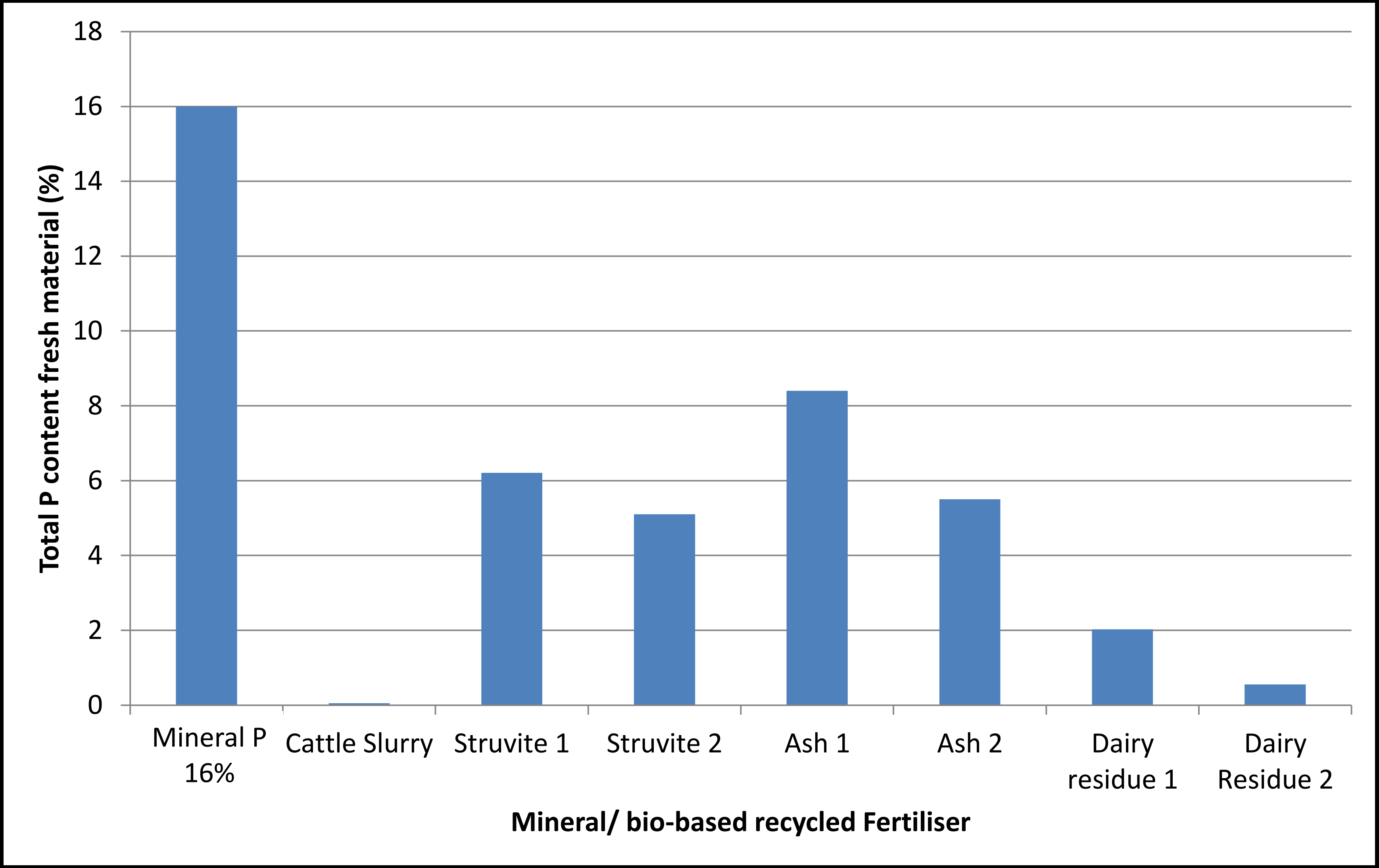
"Build-up" P, lift index 13,334 or 49%

The bio-based recycled fertilisers examined

More concentrated

	Slurry	Struvite 1	Struvite 2	Ash 1	Ash 2	Dairy residue 1	Dairy residue 2
Source	Cattle	Potato processing	Sewage sludge	Sewage sludge	Poultry litter	Dairy processing	**Dairy processing**
Dry matter %	9	58	51	100	100	25	12
Organic C	3.5	0.06	0.08	0.07	0.05	3.3	3.6
N	0.28	3.0	2.6	0.03	0.02	0.64	0.73
P	0.054	6.2	5.1	8.4	5.5	2.025	0.552
K	0.39	0.69	0.03	10.7	1.3	0.14	0.21
S	0.04	0	0	3.0	3.1	0.07	0.06

Comparative P Concentration (of fresh material)



Interreg North-West Europe ReNu2Farm

Bio-based fertiliser research and demo is on-going
Supported by EU H2020 and INTEREG

Nutri2Cycle

www.nutri2cycle.eu

Grassland:

Mineral P fertiliser replacement value of bio-based fertilisers

Demonstrate & evaluate their multi-year integration into a fertiliser programme

Arable:

Demonstrate & evaluate their multi-
integration into a cropping rotation,
on-farm collaboration

Watch on YouTube

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Grassland Field Site

Index 1	Index 2	Index 3	Index 4
Very Low	Low	Adequate	>Sufficient/High
mg/L P Morgan's extract			
0 – 3.0	3.1 – 5.0	5.1 – 8.0	>8.0

- Low fertility site selected
- Starting soil test P 2.9 mg/l Index 1 deficient
- Starting pH 5.6 – lime added at the start to bring pH to 6.1
- Randomised complete block with five replications
- 3 silage cuts and one residual cut
- A single application of 40 kg P/ha at the beginning in 2019
- N,K,S applied in accordance with recommendations

agronomy

https://www.mdpi.com/2073-4395/11/3/427

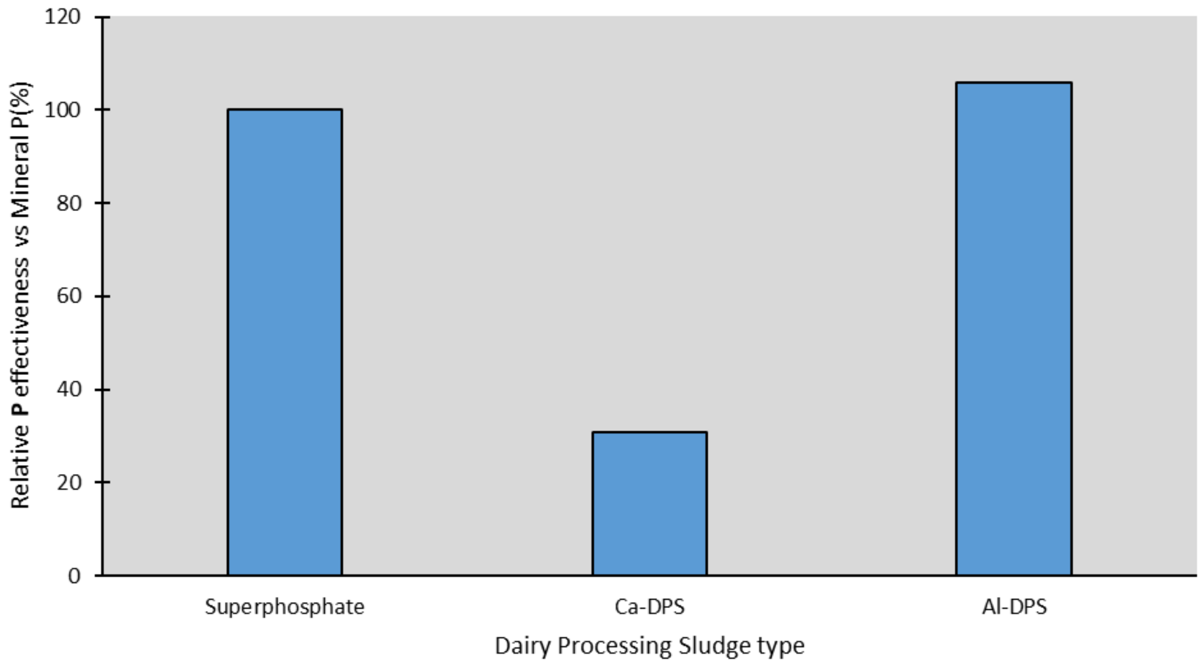
MDPI

Article

Differing Phosphorus Crop Availability of Aluminium and Calcium Precipitated Dairy Processing Sludge Potential Recycled Alternatives to Mineral Phosphorus Fertiliser

S.M. Ashekuzzaman [1,*], Owen Fenton [1], Erik Meers [2] and Patrick J. Forrestal [1]

Relative **P** effectiveness of 2 Dairy Processing Waste Precipitated Sludges compared to superphosphate (first year)



Adapted from Ashekuzzaman et al., 2021 *Agronomy: 11, 427 Table 4*

Nutri2Cycle

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Sustainable Production and Consumption 25 (2021) 363–373

Contents lists available at ScienceDirect

Sustainable Production and Consumption

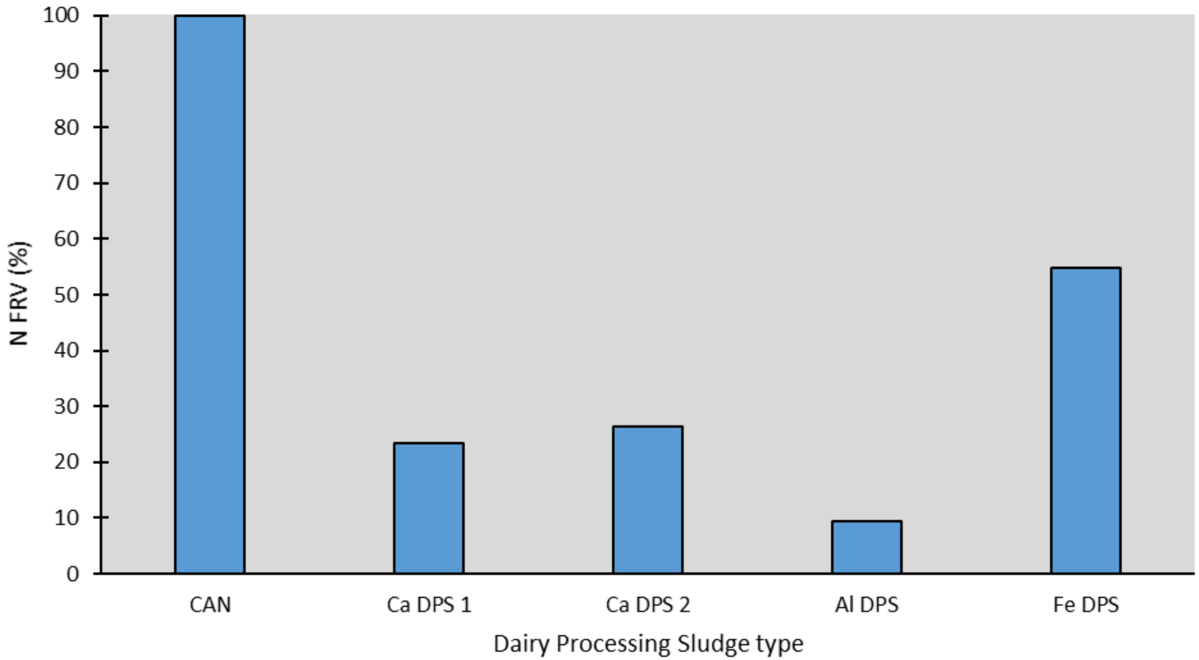
https://www.sciencedirect.com/science/article/pii/S2352550920313919?via%3Dihub

Grassland Phosphorus and Nitrogen Fertiliser Replacement value of Dairy Processing Dewatered Sludge

S.M. Ashekuzzaman*, Patrick Forrestal, Karl G. Richards, Karen Daly, Owen Fenton

Teagasc, Environment Research Centre, Johnstown Castle, Co. Wexford, Ireland

Nitrogen Fertiliser Replacement Value (N FRV) of 4 Dairy Processing Waste Precipitated Sludges compared to CAN



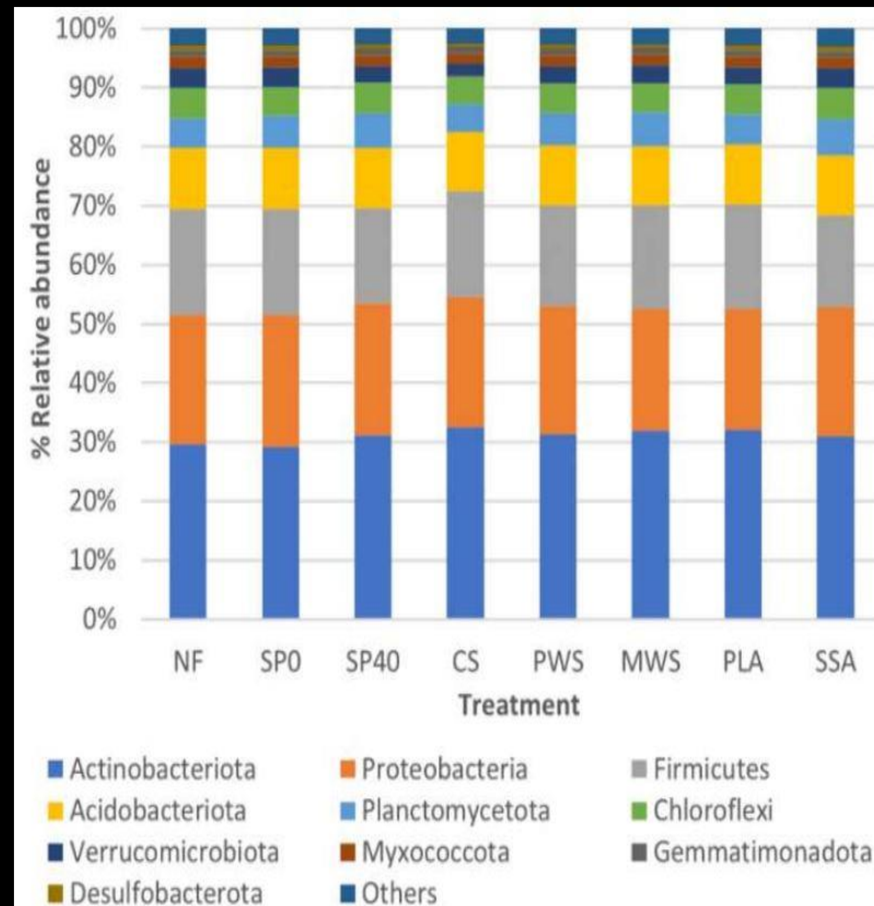
Adapted from Ashekuzzaman et al., 2021 *J. Sust. Prod & Cons. 25: 363-373*

Article

Soil Microbial and Nematode Community Response to the Field Application of Recycled Bio-Based Fertilisers in Irish Grassland

Anna Karpinska [1], Demi Ryan [1], Kieran Germaine [1], David Dowling [1], Patrick Forrestal [2] and Thomais Kakouli-Duarte [1,*]

- Bacteria diversity was maintained or enriched by use of struvite and ash RDFs
- Sewage sludge ash unfavorably affected nematode diversity
- Neither struvite impacted nematode communities



Karpinska et al. (2021) https://doi.org/10.3390/ su132212342

Conclusions

Opportunity

- Clear continued need for nutrients
- Several bio-fertilisers performing as well or better than mineral P
- Policy driver
- Potential soil health/ nutrient mineralisation opportunities
- Role in soil health
- Cost - security
- Right thing to do

Challenge

- Cost and transport
- Field validation needed, e.g. can't assume nutrient content = performance
- Field environmental performance testing needed
- Granulation
- Concentration of nutrients
- Matching crop/soil requirements
- Regulation & certification

Thank you for your attention

Questions?

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