PRODUCTION OF PHOSPHORUS FERTILISER FROM ABATTOIR AND OTHER INDUSTRIAL BY-PRODUCTS

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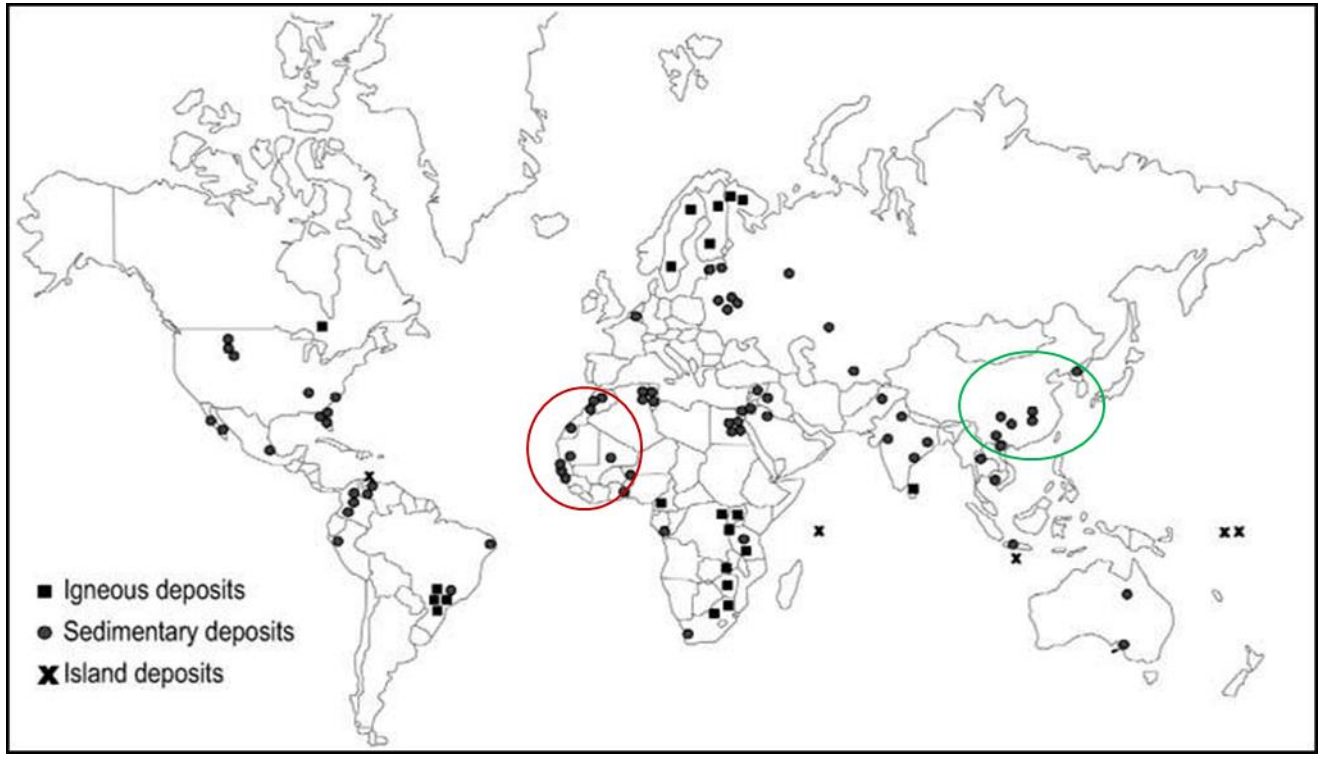
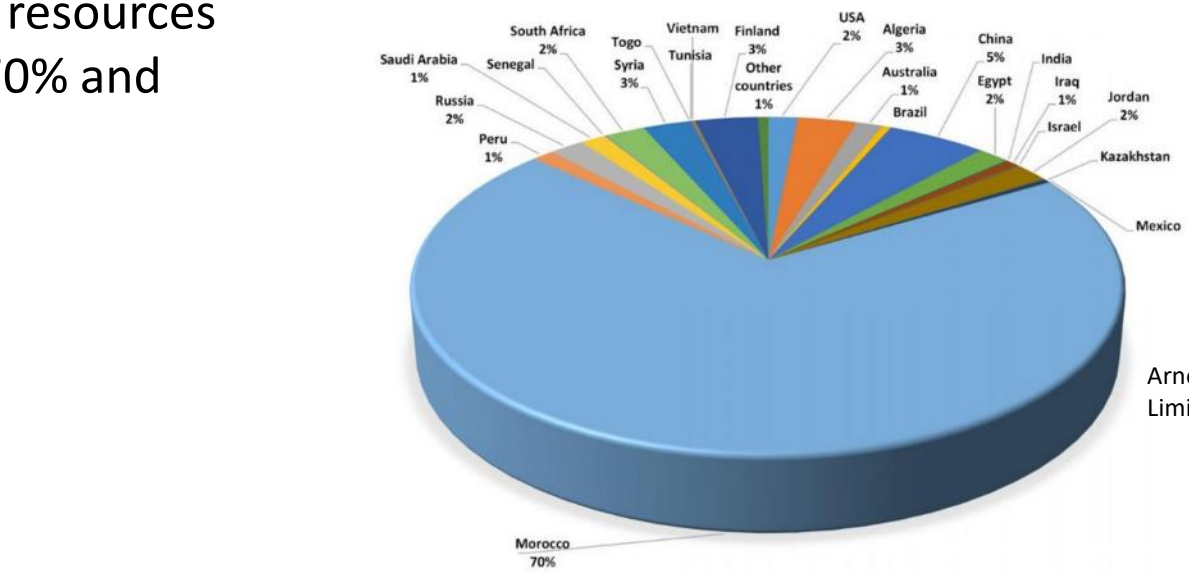
Net Zero and Resilient Farming – North Wyke
Rothamsted Research

Introduction

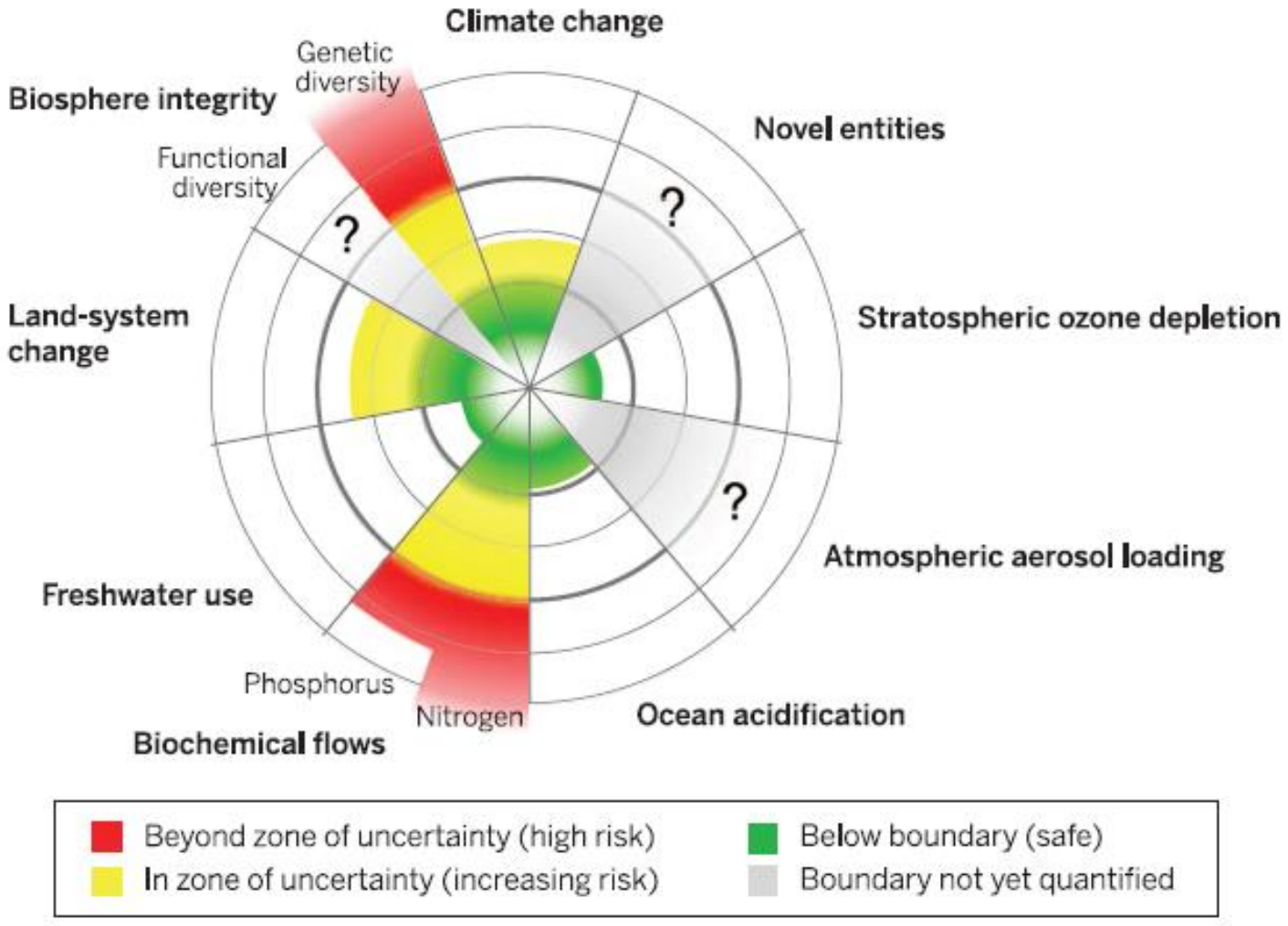
- Global food production is underpinned by phosphate fertiliser
- Primarily derived from rock phosphate
- Reserves are finite – estimates range from decades to centuries
- Not only a matter of how much is left, but where is it?
- International Fertiliser Development Centre (IFDC) state 75% of the resources are in two regions (Morocco 70% and China 5%)
- Geo-political risks





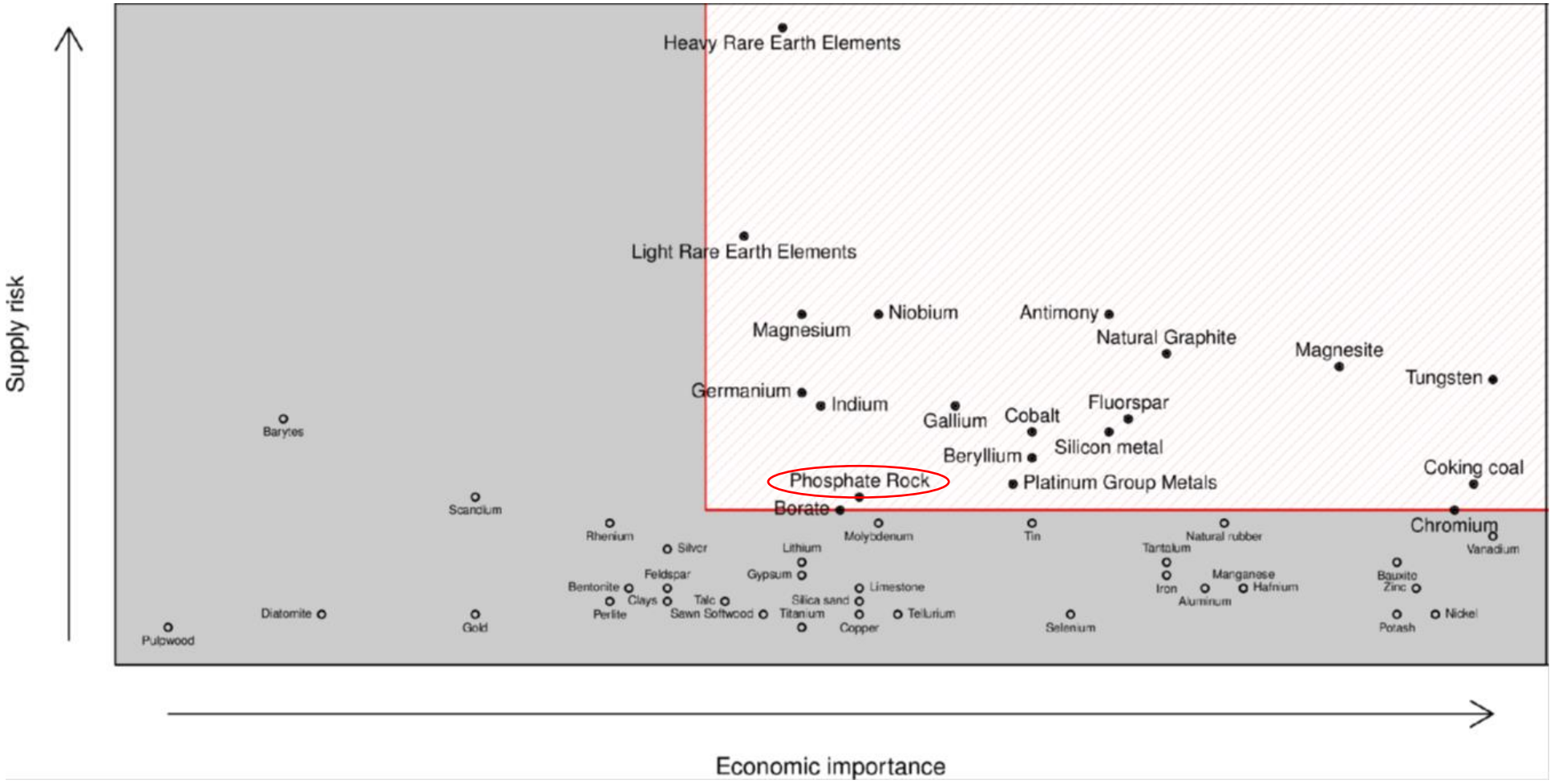
Arno Rosemarin (2016) Phosphorus a Limited Resource – Closing the Loop

Planetary Boundaries – Sustainability of the phosphorus cycle



Steffen et al., 2015. Science.

Phosphate rock – an EU critical raw material



Origins of phosphate fertiliser industry

- Need to find alternative sources of phosphorus

- First commercial phosphate fertiliser:
  - Produced by John Bennett Lawes in 1842
  - Not from rock phosphate
  - ~1% of animals are P, 80% occurs in bones
  - Dissolved animal bones in sulphuric acid (superphosphate)
  - Represented the start of the inorganic/synthetic fertiliser industry
  - Foundation of Rothamsted Research

- 181 years later – Elemental Ltd are doing something similar!

By-products from the meat industry

- Animals are slaughtered and processed at abattoirs
- Primary meat/food products are acquired – lots of leftover by-products
- What happens to abattoir by-products currently?
- Waste is transported to rendering plants and processed to recover:
    - Animal fat
    - Meat stock
  - Non-food products – often to landfill or burnt for bioenergy (e.g. low quality oil)
  - Burying bones represents a waste of potentially useful phosphorus
- Involves transport and disposal costs

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Elemental Ltd – UK company

Developed a system for processing all abattoir by-products (ABPs)

Elemental Business Overview:

Through a combination of proprietary technical and chemical processes, Elemental turns abattoir by-products into value-added end products in a two-phase process:

The first phase food extraction process rapidly recovers high quality, fully traceable beef proteins and fats for human consumption

The second phase uses the residual bone mineral and other organic wastes and converts them into a sustainable, slow-release phosphate rich fertiliser, rich in carbon compounds, sulfur and micronutrients.

Both these phases take place in purpose-built units at the abattoir.

- High quality food products (no degradation as processing is immediate)
- Almost no waste
- Only products of value transported from the abattoir

Food Extraction

The Elemental food extraction processes rapidly recovers high quality, fully traceable beef fat, beef proteins from fresh bones and meat trims. Our process increases the fat and protein recovered from each animal slaughtered, increasing yields for meat producers.

Protein and Fat Recovery

Food Products:

Food grade protein powders for use as a food ingredient & dietary supplement

Beef Broth for stocks and sauces

Residual Phosphate for Fertiliser

The residual bone mineral produced in food extraction process is then used as the phosphate source for our connected fertiliser process

Bone mineral after fats and protein have been extracted for food

Sterilised bone mineral

Sterilisation and Chemical Conversion of Fertiliser

CAT2 & 3 Animal By-Products (ABPs), such as bone, inedible organic matter and waste sludges are sterilised by a EU/UK approved high temperature and pressure process, using our patented technology.

Insoluble bone phosphate is converted to a more soluble form of phosphate through our patented technology by adding acid

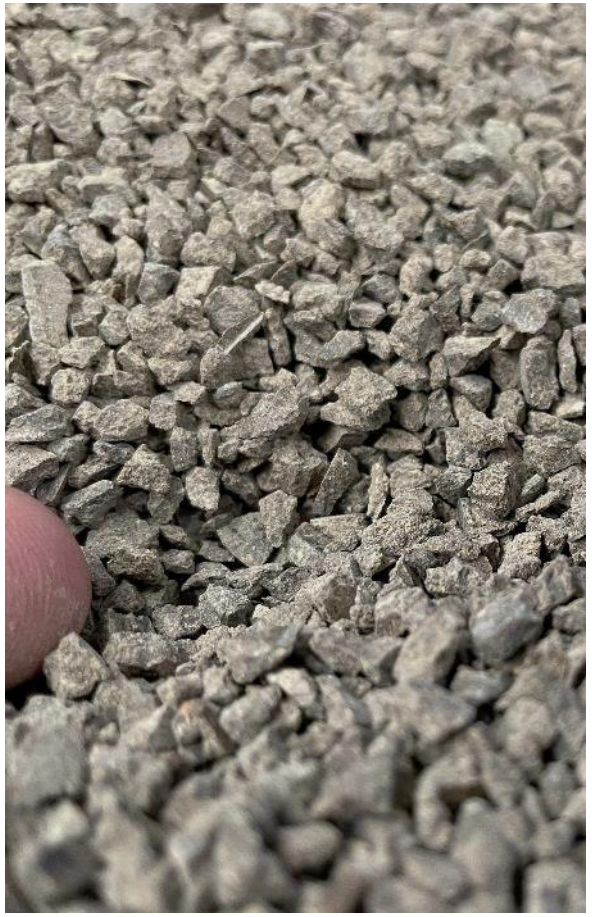
Blend Customisation

Customisation:

Once neutralised the fertiliser paste can be customised by the addition of other ingredients and or micro-nutrients to suit the market demands

Finished Fertiliser Product

Granular Fertiliser



The fertiliser is dried and reformed into dense, nutrient rich granules for farm application.

20% phosphate product for direct application or blending with N & K source products

Potential market role for fertiliser produced from abattoir waste.

- 2 million cattle slaughtered in the UK annually
- 300 million globally

- From each animal, the Stage 1 process recovers:
  - Additional ~40kg of edible fats
  - ~8kg edible protein (equivalent to ~42kg fresh meat)

- From each animal, the Stage 2 process produces:
  - ~175kg fertiliser (typically 20% P_2O_5)
  - 50 million tons per annum globally
  - Equates to 20% global fertiliser use

- But……
- Is it as good as other phosphorus fertilisers?

Experiment 1 – Comparison of fertiliser types

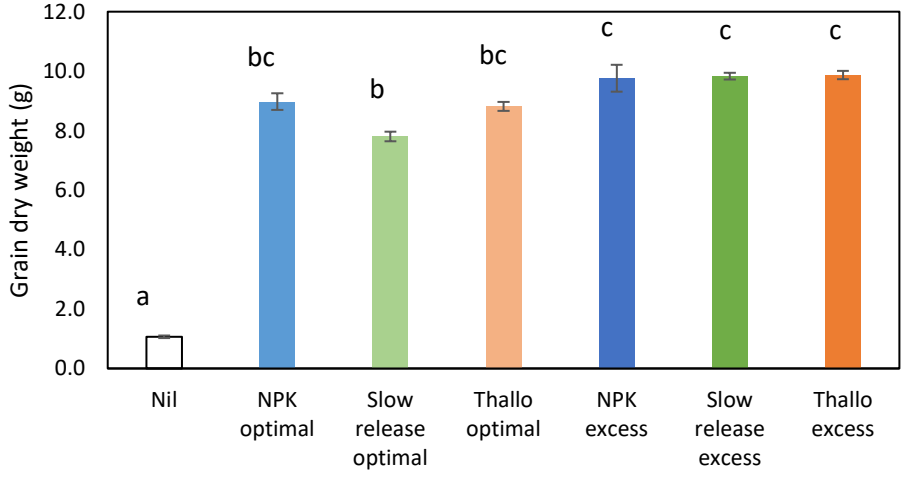
Spring wheat

Perennial ryegrass

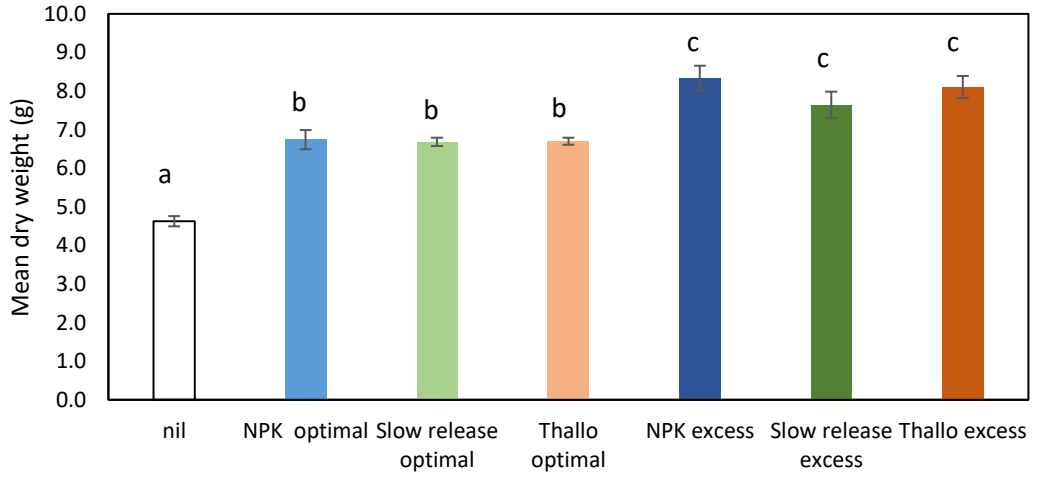
Three types of fertiliser
(NPK, Slow release, Thallo & Nil)

Two rates of fertiliser applied
(Optimal, Excess (2x))

Grain yield



Total grass biomass in soil



Darch et al. (2019) https://doi.org/10.1371/journal.pone.0221647

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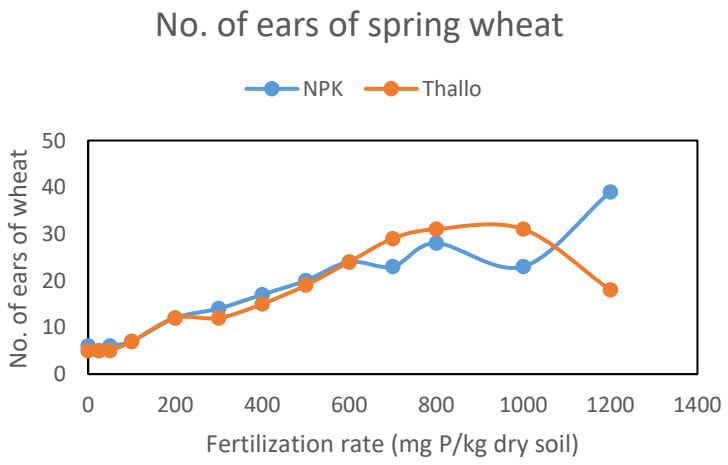
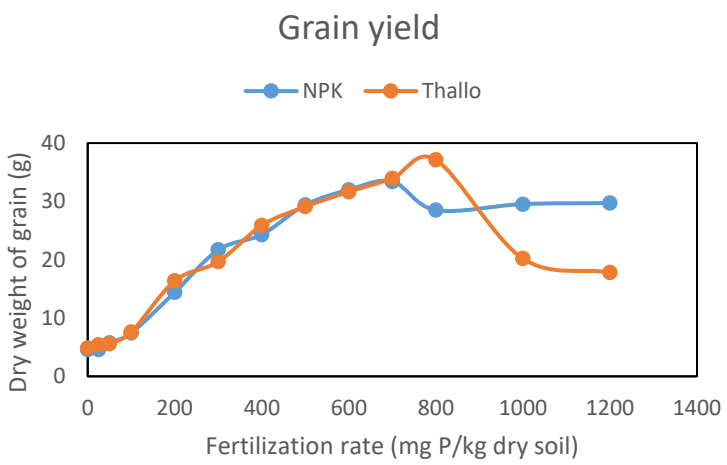
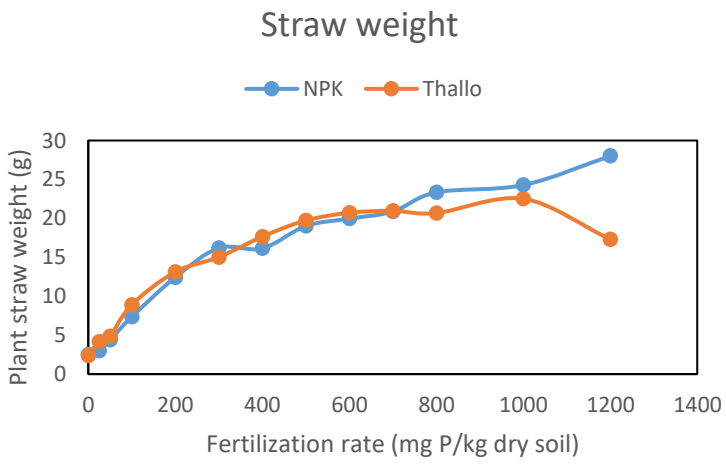
Experiment 2 – Finding optimal rates

Increases in application rate
0 to 1200mg P/kg soil
Optimal is 50 kg P/ha
Two types of fertiliser (NPK, Thallo)







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Tropical crop growth trial (Ghana) – comparison of fertilizer types

Semi-Deciduous Forest Agroecological Zone

Coastal savannah Agroecological Zone

Table 5: Effect of Thallo and NPK application on ear length, ear weight and maize grain yield

Location	Treatment	Ear length/plant (cm)	Ear weight/plant (g)	Grain yield (tonnes ha^{-1})
Jukwa	Control	13.45a	106.0a	2.12a
	NPK	17.39b	209.1c	3.70b
	Thallo	17.57b	214.2c	4.70c
	$LSD_{0.05}$	2.27	18.41	0.42
UCC	Control	16.95a	182.2a	1.92a
	NPK	17.28a	192.1a	3.81b
	Thallo	19.19b	223.5b	4.62c
	LSD	1.03	29.08	0.60

Means followed by the same letter in each column are not significantly different at $p \leq 0.05$ using Fisher's unprotected LSD

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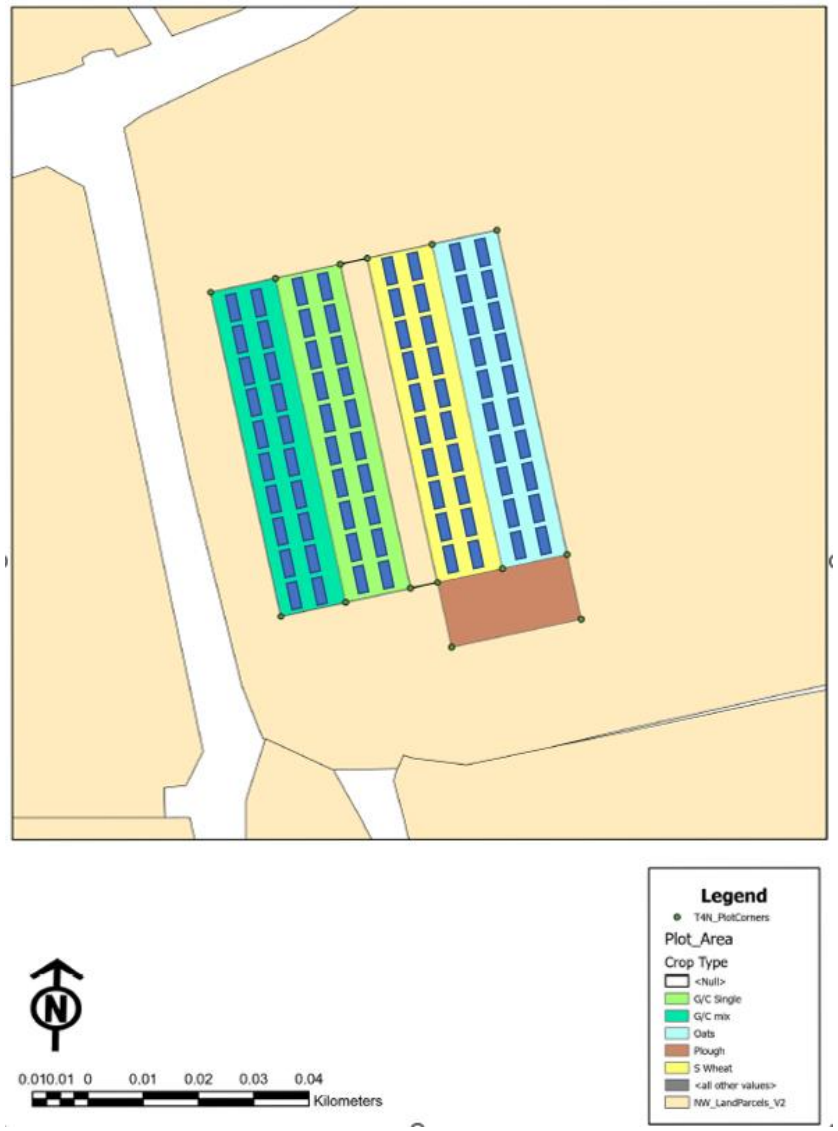
Trans4num trial



Four crops

- Spring wheat
- Spring oats
- Grass & white clover (single variety)
- Grass & white clover (multiple varieties)

Three fertiliser types

- Standard NPKS
- Thallo (topped up as required)
- Cattle manure (topped up as required)
- Nil control

Five replicates of each crop and treatment

Sown 18th April 2023

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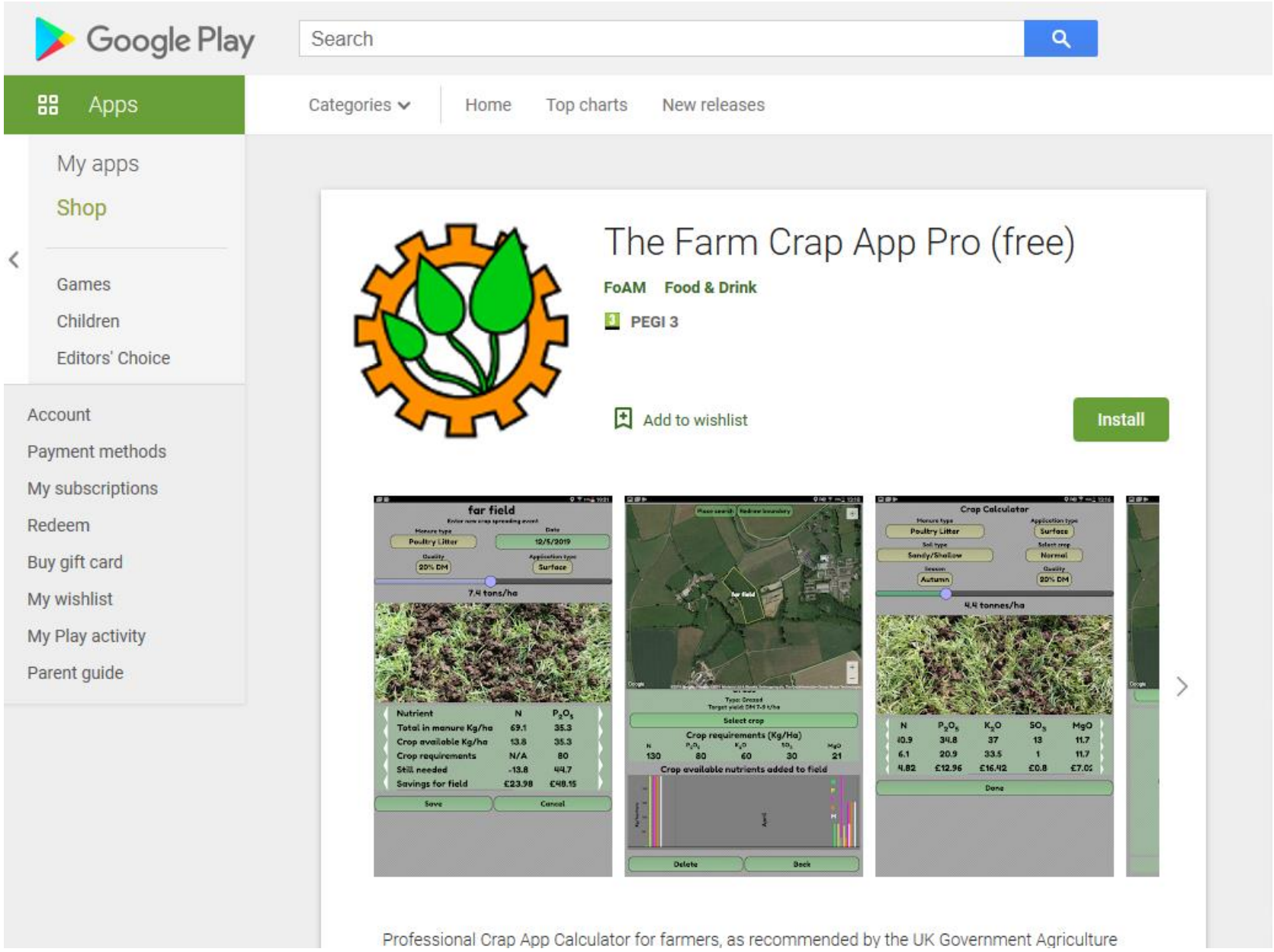

Trans4num trial

Allows in-field adjustments to be made

Value: 27 m3/ha

Nutrient	Crop Available	Total In Manure	Crop Requirements	Still needed	Savings
N Kg/ha	19.44	43.2	20	0.56	£71.67
P_2O_5 Kg/ha	16.2	16.2	55	38.8	£21.09
K_2O Kg/ha	45.9	45.9	145	99.1	£47.23
SO_3	2.84	8.1	0	-2.83	£8.33
MgO	5.4	5.4	0	-5.4	£5.56

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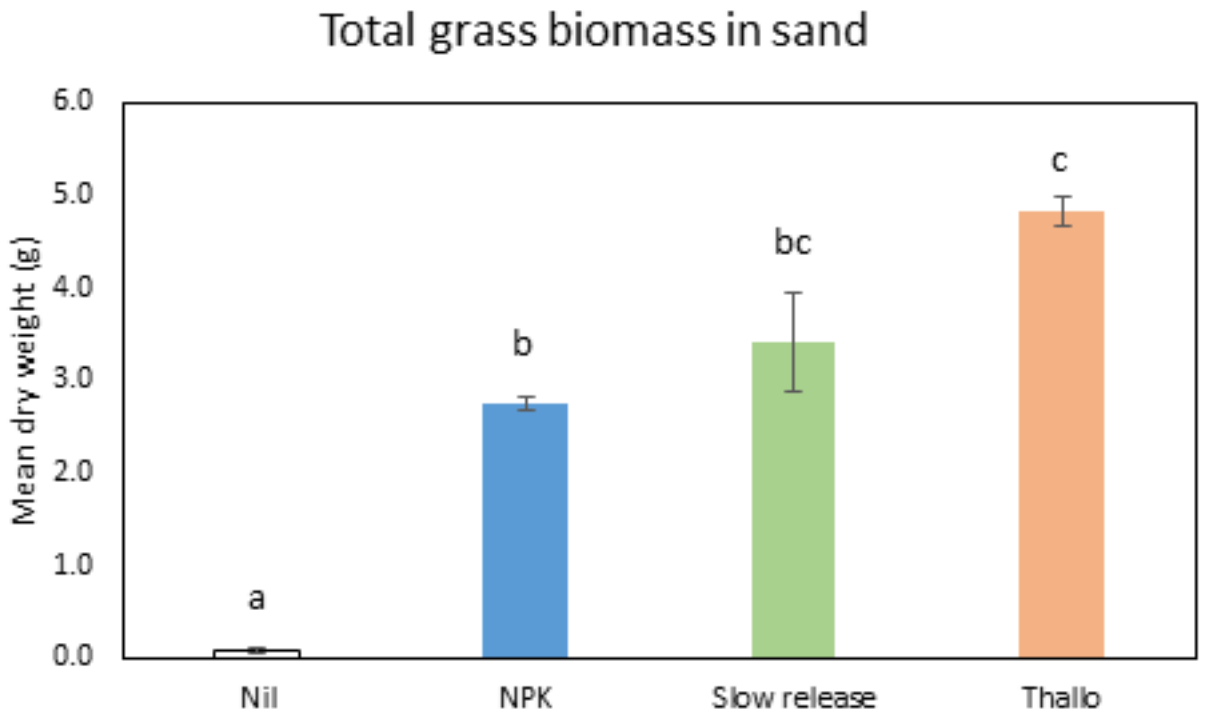
Grass grown in sand



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