FROM ANIMAL WASTE TO PLANT NUTRITION

Summary

Domestic livestock make a number of valuable food and material products, but at the end of their life the skeleton and unused parts are often lost from the agricultural system. The bones of animals contain a valuable resource in the form of hydroxyapatite - a form of calcium phosphate. Conversion of the hydroxyapatite into a plant available form of phosphorus can be utilised to produce a fertilizer. Field trials have demonstrated that the use of this type of phosphorus has a comparable benefit to crop yields as conventional phosphorus fertilizers.

The need

Fertilization is one of the key components in modern agriculture. Without the application of fertilizers, crops must utilise what nutrients are available within the soil. High yielding crops quickly deplete the reserves of nutrients found within the soil, and natural rates of deposition are not sufficient to replace what is being taken out of the system within the crops. Therefore, the nutrients must be replaced with fertilizers in order to maintain the yields necessary to feed the population.

Mining allows vast mineral resources to be relatively quickly pulled from the ground and processed into material that is both easy for farmers to apply to their crops, and accessible by the plant roots. However, two problems exist with the primary resource used to manufacture phosphorus fertilizers - rock phosphate.

Firstly, 80% of the global reserve of rock phosphate is found in Morocco and Western Sahara, and geopolitical tensions in this area mean that supplies may be interrupted at short notice. Secondly, rock phosphate sometimes has a high cadmium content, and contamination of land with this heavy metal needs to be avoided.

The recycling of phosphorus from animal bones into a phosphorus fertilizer would avoid these issues.

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The benefits

The alternative phosphorus fertilizer used in this field trial has a number of benefits compared to the use of rock phosphate as a raw ingredient.

Firstly, the recycling of waste material from the livestock industry can provide an alternative source of phosphorus to the mining of rock phosphate. Sufficient production to meet the entire needs of an individual country is unlikely, but could form the foundation of a phosphorus fertilizer production system across many countries.

Secondly, the cadmium contamination of agricultural soils would be avoided if a significant proportion of the phosphorus needs are met by applying a fertilizer that does not contain this contaminant.

Thirdly, the use of animal bones and other material from abattoir systems, when used to manufacture a fertilizer, will also contain some of the other nutrients required by the crop plants. For example, the total phosphorus and sulphur needs of a winter wheat crop can be met with this single fertilizer, as well as 6% of the crop's nitrogen requirement and 8% of its potassium needs. This would have the dual benefit of reducing the use of the world's resources for agriculture, as well as cutting the costs to farmers when buying multinutrient fertilizers.

Lastly, should a new industry be developed that uses a waste material from the livestock industry to manufacture a useful product, it could increase the monetary value of each animal being produced.

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trans4num solution

A field trail over multiple years was undertaken at the Rothamsted Research experimental station located at North Wyke in the south west of England. A grass silage system as well as pre-winter sown arable crops were utilised in the trial.

Three fertilizer application regimes were used in the trial:

- Standard fertilizers available on farm and all commercially available,
- A novel fertilizer manufactured using waste material from the livestock industry,
- A nil input control to allow the crops to grow using only what was available within the soil.

Standard fertilizer application rates were utilised in the study following the U.K. government's fertilizer recommendations for each particular crop. Soil samples were taken prior to any fertilizer applications, and only what was needed to meet the nutrient needs of the crop was applied. Four main nutrients were included in the trial: phosphorus, nitrogen, potassium and sulphur.

Where the **novel fertilizer** did not meet the requirements of the crop being grown, the commercially available fertilizers were added to supplement what was needed. This resulted in the total amounts of the four nutrients being applied at the same rate in the fertilized plots, with only the form of the application differing between treatments.

The results from the field trials illustrate that the fertilized crops produced better yields than the **nil fertilized** control plots. There were no significant differences between the two fertilizer treatments for grass silage or winter wheat crops.

We can conclude that the use of a novel fertilizer manufactured from animal waste materials such as bones can be used to produce a fertilizer that is comparable to the standard phosphorus fertilizer available on the market today. Detailed nutrient analysis will be undertaken to examine whether there are any beneficial effects on the crop when using the novel fertilizer, as was found in controlled environment pot trails when using this product (Darch et al., 2019, Frimpong et al., 2024).

What were the challenges / limitations in the implementation process?

- **Business development issues>:** technical challenges of getting a product to market
- **Consumer acceptance:** difficulty in shifting users from a known product to a novel product
- **Economic issues:** high energy costs associated with manufacturing
- **Farmer mindset:** historical use of commodity pricing to determine the purchase and use of phosphorus fertilizers

What kind of resources do you need to implement the proposed solution?

- **Government support:** tighter control on phosphorus applications to crops in light of recent eutrophication of rivers in the U.K. involving phosphorus.
- **Business Development Strategy:** government support for Small and Medium Sized Enterprises to break into an existing market.
- **Knowledge Exchange:** effective interpretation and presentation of scientific evidence to persuade agronomists to use a novel fertilizer.

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More information

- Darch, T., Dunn, R.M., Guy, A., Hawkins, J.M.B., Ash, M., Frimpong, K. A. & Blackwell, M.S.A. (2019) Fertilizer produced from abattoir waste can contribute to phosphorus sustainability, and biofortify crops with minerals. Plos One, doi.org/10.1371/journal.pone.0221647.t001
- Frimpong, K.A., Dunn, R., Noel, A., Phares, C.A., Abban-Baidoo, E. & Blackwell, M. (2024) Investigating the comparative effects of abattoir waste (ThalloTM) organomineral fertilizer and inorganic NPK fertilizer on wheat grain and ryegrass yields and their nutrient uptakes. International Journal of Recycling Organic Waste in Agriculture, doi.org/10.57647/j.ijrowa.2024.1302.20

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