Institute of Organic Training & Advice

Results of Organic Research: Technical Leaflet 7

Composting with rock phosphate: increasing plant-available P

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Introduction

Organic farmers and growers need to ensure adequate availability of phosphate (P) from the soil in order to support the metabolic, energy and transport processes essential to plant growth and also for optimum functioning of soil organisms, such as nitrogen fixing rhizobia. Organic producers' principle aims in relation to P are to:

1) optimise the utilization of whatever P is in the soil, and,

2) maximise recycling within the farm through the careful use of own manures and minimising losses from soil by soil erosion and leaching.

Inevitably there is an off-take of P from the farm in the form of crops and livestock products, P which is supplied from the soil. Under organic farming there is no opportunity to recycle this P due to the current prohibition of human manure by the organic standards.

Compost turning with a foreloader

The capacity of the soil to supply P will depend partly on the level and availability of soil P, which will be influenced by the inherent soil type and to historic applications of P, which may have resulted in the build up of large reserves. This will influence the need to bring P onto the farm in the future, there being evidence that less intensive systems and those bringing in P in the form of straw or animal feed can operate, at least in the medium term, without further additions of fertiliser P. However, if soil P levels are declining or if the soil type is just inherently too low in P for the planned cropping, then organic farmers supplement plant-available P with brought-in manures, green waste compost or mineral rock phosphate (RP), such as Gafsa.

RP is insoluble in water and hence the P it contains is only slowly available to the plant, especially on neutral and calcareous soils. Consequently an application of RP may be insufficient to meet the short-term needs of demanding crops such as potatoes on a P deficient soil. Grinding RP to a powder helps alleviate this problem if the source of the RP is classified as being of a low to moderate reactivity, however, availability remains relatively low.

In an effort to improve plant availability and overall utilisation there have been a number of research projects which suggest that by applying the RP to the compost heap (co-composting) the availability of P is increased. This Technical Leaflet draws on that research and in particular the P-Link project that undertook the most detailed laboratory analysis and field trials ever

This Technical Leaflet is one of a series of leaflets for farmers and growers which summarise practical recommendations arising out of research. It draws on the results of the Defra funded P-Link project led by the Scottish Agricultural College and it is produced in collaboration with the Institute of Organic Training and Advice.

Other Leaflets in the series produced under this project and the Defra funded PACA Res project include: Phosphate Management Using Green Manures, Composting, Dairy Cow Nutrition, Financial Management, Nutrient Budgeting and Beef & Sheep Nutrition. For further information go to the IOTA website www.organicadvice.org.uk/research_results.htm

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conducted on the use of co-composting to enhance P availability in the UK (see **Text Box 1, below).**

The aim of the P-Link project is to develop better means of controlling the release of P from added materials.

P-Link Trials

The P-Link project undertook a series of trials assessing the effect of co-composting RP on the solubilisation and availability of P to plants:

- Laboratory trials with compost and RP
- Pot trials with aerobic and anaerobic composts plus RP
- Commercial green waste compost trials with RP
- Farm scale composting trials
- Farm based plot trials assessing the effect of added RP to P uptake and crop yield

In addition, P-Link undertook plot and field trials to assess the ability of different green manures to improve the availability of P from co-composted RP.

P-Link Trials

The effect of co-composting rock phosphate

The behaviour of P in the soil and in compost is exceedingly complex and not fully understood. P may be present in various inorganic and organic forms between which it is interchangeable due to biological activity. The plant availability of soil P is further influenced by soil type, pH and the presence of organic acids. In some forms it is readily available to the plant, in others it is less available especially under alkaline conditions. Composting and fermentation favour the release of organic acids by microbial activity and these both dissolve RP, releasing plant-available forms of P and make the P prone to temperature induced weathering.

There is existing evidence that an important outcome from co-composting is the maintenance of P in a potentially plant-available form through the uptake and storage of P in the microbial biomass, which is subsequently turned over making the P available. When co-composting RP, the initial dissolution/decomposition phase is followed by uptake, transformation and storage of solubilised P within the microbial biomass, and finally a variable period of stabilisation and humification of organic P-containing compounds, the extent of which will depend on storage conditions and duration. The P-Link project demonstrated this increase in P availability with pot experiments showing that between 10 and 20% of the RP applied was solubilised into plant-available P forms.

Management of P through co-composting

There appears to be scope for farmers and commercial composters to enhance the availability of applied RP by simply adding it to the compost heap. Unfortunately, it is not quite as straight forward as that! The P-Link project undertook field trials with compost from a green waste compost site, turning compost with a material handler (see **Text Box 2, below**).

Green Waste Composting Trial

Site: Organic Recycling Ltd

- 1:3 mix of straw and brassica waste
- With 3% by dry weight RP added and without added P.
- Uncovered windrow on a concrete base.
- Fore loader turned roughly 3 times over 10 to 14 weeks to meet PAS 100.
- Applied at 8 tonne/ha supplying 100 kg (with RP) and 20 kg P/ha (without RP).

Green Waste Composting Trial

The project also assessed farm produced compost based on manures and green waste using Controlled Microbial Composting methods, using a specialist compost turner (see **Text Box 3, below**).

On Farm Composting Trials

Site: Blaen Camel

Ingredients: 33% green material (vegetable waste, grass and clover mowings), 33% straw based horse manure, 33% other material including wood chip, waste hay etc. Inoculated with CMC bacterial inoculant.

Site: Holme Lacy College

Ingredients: Straw based cattle FYM, Straw based horse manure, green waste, soil. Not inoculated.

Both sites used:

- 3% by dry weight RP added and without added RP.
- Toptex covered windrow.
- Sandburger compost machine turning 8–10 times over 8 weeks.
- Protocol – Controlled Microbial Composting.

On Farm Composting Trials

The trials found that although adding RP to the compost inevitably resulted in an increase in total P, and initially an increase in P availability, by the end of the composting process microbial P was not increased and the quantity of P available to the plant actually decreased (see **Figure 1: On Farm Composting trials** on page 4).

Previously it was thought that the reduction in plant-available P found after adding PR was due to an increased amount of P in the organic microbial fraction, which would subsequently be released to the plants. However, the P-Link project has shown that this is unlikely and that it is probably due to a combination of factors including chemical combination. It is thought that the solubilised P from the added RP is being held in some chemical form that is likely to have developed as a result of calcium and carbonate from the added rock interacting with the humic materials in the compost. The subsequent availability of this bound up P and the long term fate of this P remains uncertain.

The inoculation of co-composted RP and organic material with selected micro-organisms also has potential to improve the availability of P. The P-Link trials indicated that inoculation with *Aspergillus niger* produced further small increases in plant-available P by solubilisation of the RP. What was of note was that the application of PR directly to the soil improved the supply of plant-available P.

The effect of compost storage conditions on P availability

There is evidence to suggest that after the initial peak in P availability during composting, there is a series of secondary reactions which, depending on the compost ingredients, may reduce the availability of P over time. In the P-Link trials levels of plant-available P declined by 50% over a 12 month period. However, there was no indication that the storage conditions had an effect on P availability: both aerobic and anaerobic storage conditions produced the same decline. The main influence was the effect of the conditions at the start of composting. When the compost had been started under anaerobic conditions there was subsequently a greater reduction in P availability, which could occur if the piles were covered and left unturned, than if the compost was aerobically managed from the start. Once applied to the soil the subsequent long-term availability of P is unknown, although the co-composting may have caused the P in the RP to be more available in the long term than if it was not co-composted.

Applying some of the P in a form which is initially not available to the plant may well have benefits in terms of reducing possible loss from the field as well as providing a more accessible long term P supply.

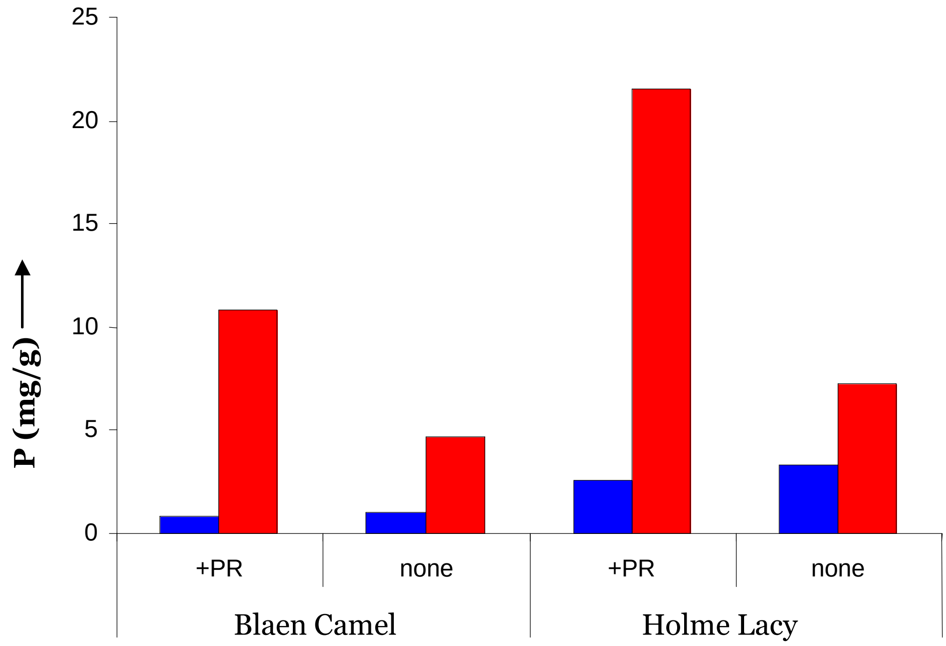

Figure 1: *On farm composting trials at Blaen Camel and Holme Lacy. The recovered levels of plant available P (Blue) and total P (Red) are shown for compost piles to which PR either was or was not added.*

Practical recommendations

It is not yet possible to provide precise guidelines on the role and management of co-composting rock phosphate due to the limited knowledge of the complexity of the chemical and biological processes involved, which have lead to unpredictable results. However, co-composting clearly changes the form and availability of the P in RP and there are some management techniques that we can identify which might be beneficial in improving the availability and the timing of release of P from applied RP. To summarise:

- Co-composting can improve P availability, although results may be unpredictable and short-term.
- The solubilising effect and the availability of P will be influenced by the compost ingredients: brassicas are particularly effective at solubilising P. Keep the constituents of the compost fixed if consistent results are to be achieved.
- The composting process itself will have an impact: ensure that optimum moisture levels, thorough mixing and turning frequency is maintained.
- Adding more RP to the compost will not necessarily increase available P, but may provide improved long term P supply.
- Addition of specific microbial inoculum enhances availability, but possibly not greatly.
- Anaerobic fermentation increased the availability of P compared with aerobic composting, but there may be negative consequences that make this approach undesirable.
- Calcareous soils will tend to lock up P.
- There will be some decline in plant-available P with storage over a 12 month period, but this decline is the same under both anaerobic and aerobic storage conditions.

The P-Link project worked with Gafsa RP (one of the most reactive calcium phosphates) and these conclusions may not apply to other forms of RP that are less reactive.

There are some additional handling costs involved in adding RP to the compost heap rather than adding it directly to the soil. Composting itself is an expensive operation and in those circumstances where composting is not normally carried out it may not be economic to pursue this as a means to alter P management. However, PR addition to compost may provide opportunities to alter the N:P ratio of a compost material and allow for energy saving through single application of both nutrients.

There may be potential to improve P management over the longer-term by co-composting RP and then exploiting the potential of certain green manures (e.g. brassicas, buckwheat) to take up significant quantities of P for release to a subsequent high P demanding crop. Regular soil analysis is an important tool for managing soil P, providing information to help identify the most appropriate management practices and for monitoring long term changes in soil P.

Sandberger Compost Turner

Key references

1. Research references

P-Link Project

2. Useful sources of further information

Searchable archive of organic research reports: Organic Eprints www.orgprints.org

PACA Res Research Reviews:

Compost: the effect on nutrients, soil health and crop quantity and quality: www.organicadvice.org.uk/papers/Res_review_3_compost.pdf

The role, analysis and management of soil life and organic matter in soil health, crop nutrition and productivity: www.organicadvice.org.uk/papers/Res_review_16_soils.pdf

*Laboratory mineral soil analysis and soil mineral management in organic farming:*www.organicadvice.org.uk/papers/Res_review_15_soils.pdf

The Management of Phosphate in Organic Farming workshop papers: www.organicadvice.org.uk/June_workshops.htm

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