Institute of Organic Training & Advice

Results of Organic Research: Technical Leaflet 5

Compost: The Effect on Nutrients, Soil Health and Crop Production

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Introduction

This Leaflet is based on the PACARes research review "Compost: the effect on nutrients, soil health and crop quantity and quality". It is intended to provide a short practical guide on what compost is, what it does and when to use it.

Article 12(1) (b) of the new EU Organic Regulation (No. 834/2007) states that "the fertility and biological activity of the soil shall be maintained and increased by multi annual crop rotation including legumes and other green manure crops, and the application of livestock manure or organic material, both preferably composted, from organic production."

Figure 1: *CMC ® composting using a Sandberger turner.*

Article 3(1) of the Implementing Rules (No. 889/2008) states that "where the nutritional needs of plants cannot be met by measures provided for in Article 12(1) (a), (b) and (c) of Regulation (EC) No. 834/2007, only fertilisers and soil conditioners referred to in Annex I to this Regulation may be used in organic production and only to the extent necessary. Operators shall keep documentary evidence of the need to use the product."

The Annex permits, amongst other things, the use of :

- Composted animal excrements, including poultry manure.
- Composted farmyard manure (i.e. with bedding).
- Composted or fermented mixture of vegetable matter.
- Composted or fermented household waste.

All this is rather dry, but has been included in this Leaflet to illustrate the boundaries set out in the prevailing organic legislation.

There is a clear emphasis on the use of composting wherever bulky organic materials are used, although the Annex does also contain a reference to farmyard manure, i.e. non composted by implication.

This Technical Leaflet is one of a series commissioned and prepared by the Institute of Organic Training & Advice (IOTA) as part of its Defra-funded PACARes (Providing Access, Collation and Analysis of Defra Research in the organic sector) project. The PACARes project aims to improve awareness and uptake of organic research by farmers. For more information go to www.organicadvice.org.uk/pacares.htm

The Leaflets aim to provide a summary of the key practical recommendations for organic farming, drawing on the findings of research including IOTA's own Research Reviews commissioned for the PACARes project. Other Leaflets in the series include: Dairy Cow Nutrition, Financial Management for Organic Farms, Nutrient Budgeting, Organic Beef and Sheep Nutrition and Soil Analysis.

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There is no reference to sewage sludge which means it is not currently permitted. In the UK there has been little experience of working with fermented organic materials, such as those that have passed through an anaerobic digestion process, so reference will not be made to them

In the case of composted household waste there have been few, if any, instances of it being used because of issues relating to the possibility of GM residues in the waste stream.

This Leaflet will deal with the materials that are in current use in the UK.

Definitions

Materials

Compost

Solid particulate material that is the result of composting, that has been sanitised and stabilised and that confers beneficial effects when added to soil and/or used in conjunction with plants.

Composting

Process of controlled biological decomposition of biodegradable materials under managed conditions that are predominantly aerobic, the respiration of thermophilic compost organisms raising temperatures and producing a compost that is sanitary and stable.

Green and wood waste

Vegetable waste from gardens and municipal parks, tree cuttings, branches, grass, leaves (with the exception of street sweepings), sawdust, wood chips and other wood waste that is not treated with heavy metals or organic compounds.

Manure

Animal excrement which may contain large amounts of bedding.

Slurry

Consists of dung, urine and water with only small amounts of bedding.

Processes used in the UK

Passive composting

The stacking of material (often manure or mixtures of manure and other organic materials) in heaps, windrows, etc. without turning until a measure of breakdown is achieved. Full breakdown can take up to 2 years and in the great majority of cases only partial breakdown is achieved before it is applied to the land. This essentially passive approach can be seen on the majority of organic farms thanks in part to an acceptance by certifying bodies that it breaks down sufficiently over 6 months for the material to be regarded as 'composted.'

Open windrow

The most common approach to active on-farm composting adopted in the UK. Windrows are long narrow piles formed by front bucket machines (tall windrows) or specialised turning machines (low wide windrows). The composting period takes between 12 and 20 weeks with regular turning and re-mixing. There is no particular protocol for how frequently the compost is turned, nor is there any particular prescription for feedstock materials.

In-vessel composting

Represents a group of composting systems that share the common feature of enclosed containers, bins, tunnels, etc. with a controlled air supply that can take the raw material through the active composting phase in around 14 days. Maturation is typically carried out in piles or windrows. These systems generally give rise to higher quality and less variable composts, but the costs currently rule out their regular use in organic agriculture.

Controlled Microbial Composting® (CMC®) System

A development of the open windrow process, described above, by the Luebke family in Austria. It is a covered windrow system that produces finished compost in 6-8 weeks (Diver, 2001). The feedstocks are carefully chosen to include a balance of well-structured materials with an overall carbon- nitrogen ratio of around 30. Typically this will include a proportion of nitrogen-rich green material such as grass cuttings, crop wastes, etc. along with a proportion of carbon-rich material such as shredded hedge prunings. A small amount of clay or clay rich soil can be

added to assist the buffering of pH and labile nutrients and a starter culture used to establish a desirable population of micro organisms. The other key area of control is the close monitoring of temperature, moisture content and carbon dioxide production. The windrows are turned every time the internal temperature exceeds 60°C and maturity is gauged using temperature and by monitoring temperature and CO_2 emission levels. This is clearly a resource intensive system but it does give a relatively uniform product within a relatively short period of time.

Results from research

It is clear from the Research Review and the other reviews and papers it considered, that the use of compost in the sense of the full definition has considerable potential for improving soil chemical and physical properties. These effects are not always demonstrated in every research project reviewed, but taken overall we can see a range of useful benefits. It is also the case that some assumed benefits do not manifest themselves; the use of compost to provide significant quantities of available nitrogen is a case in point.

A number of conclusions can be drawn from the research projects considered in the Research Review, but this Leaflet will focus on those aspects that are of practical use and/or benefit to producers and advisers. This will be an attempt to distil those aspects that are of clear benefit from the wide body of work that has been carried out and also to provide some guidance on what could be seen as the negative aspects of compost use.

Many producers believe that they are producing composts when all they are doing is stacking manure, uncovered for a period of time and with perhaps a single turn of the heap. There is nothing wrong with this approach in principle, but it should be recognised that stacking such material in the open carries a considerable risk of nutrient losses through leaching and/or volatilisation.

Recommendation

In situations where stacking is seen as the easiest and cheapest way of managing manure, consideration should be given to covering the heaps with breathable covers such as Gore-Tex® or to the use of redundant farm buildings, if available.

Figure 2: *Turning compost by hand after 6 weeks.*

This in turn carries considerable implications for environmental pollution not to mention the loss of useful nutrients (K and N) from the system. The method has the very real benefit of being cheap and to some extent it optimises the recycling of nutrients (those that are not lost) around the farm. For these reasons, it is unlikely to be replaced by other methods on many farms.

Potassium and Phosphorus

The application of compost is likely to provide useful amounts of potassium and phosphorus, but it is clear from the work that has been reviewed that its contribution to available nitrogen status is moderate at best. It is possible to provide sufficient nitrogen for an annual crop but the quantities of compost required risk the over-application of phosphorus and potassium. Management of the composting process is crucial to maintaining the potassium status of the final product.

Potassium does not get bound to any great extent during the composting process and is therefore always present in a soluble form. The key to preserving useful quantities of potassium, often a limiting factor in organic systems, is the prevention of leaching and again the use of covers should be considered to prevent losses via this route. It should also be noted that compost made with a

Recommendation

In an ideal world, producers would take complete control of the composting process and the feedstock used. The process would be managed to minimise potassium losses and rock phosphate included in the feedstock where soil phosphorus status is particularly low.

It is important that an accurate assessment of soil nutrient status is available if the best judgements are to be made in terms of quantities to be applied (to prevent excessive phosphorus accumulation for example).

Stockless cropping operations should seriously consider the use of fresh grass and straw based composts as a way of addressing the potential potassium deficits that can build up in such systems in the absence of animal manures.

combination of grass and straw can contain twice the potassium of chicken manure.

A case has been made in the literature for calculating compost inputs on the basis of the impact on P status to avoid the build up of excess phosphorus over time. On the other hand, the mixing of rock phosphate with the compost feedstock is likely to increase its solubility and hence phosphorus availability in situations where available soil P is very low. This kind of approach is only possible where the compost is made on-farm, i.e. where there is total control over both process and materials.

Compost management

A minority of producers are using a more disciplined approach to on-farm composting. Some are working to biodynamic principles, some are using the CMC® approach and others have developed their own approach working from first principles. In the first two examples the requirements are laid out in some detail and close observance leads to the production of a consistent and easily handled product.

In the *ad hoc* category good results can also be obtained by paying attention to carbon-nitrogen ratios, regular turning of the heaps or windrows and ensuring that the feedstock is finely shredded where possible.

The requirements for initial preparation, regular turning and close attention to monitoring all add significantly to the cost of production. In general terms, the practitioners consider this to be money well spent as they are convinced of the benefits and the advantages over stacked manures. Many claims have been made for such composts, especially the CMC® derived materials but it should be clearly understood that these have not all been confirmed through research, past or current.

Benefits from the use of compost

It is however quite clear that compost can confer a range of benefits on soils and cropping systems. These include positive effects on a range of beneficial micro-organisms, soil physical properties and, as seen above, the nutrient status of the soil. Some of these benefits are clear cut, others less easy to demonstrate. It is also clear that the variable nature of the materials described as compost in the range of projects and trials covered by the various reviews, means that many of the positive benefits cannot always be demonstrated. There are also a number of papers that refer to the negative effects on soil properties, crop yields, etc.

A further conclusion to be drawn from the large body of work is that while most positive effects can be demonstrated following one application of compost, it is the regular and continuing applications year on year that bring lasting change to the system. This is particularly

Recommendation

Producers that buy in compost in the form of green waste compost or other types of compost acceptable under the organic standards can gain some assurance of product nature and consistency from the fact that the great majority of materials are produced under the PAS 100 standard.

That said, analyses of the materials concerned should be undertaken to see if the pH, nutrient status, etc. are appropriate to the soil type and cropping system concerned.

true when considering the effects upon soil organic matter levels, cation exchange capacity, structural stability, etc.

Compost versus manure

This Leaflet has focused on compost but in the course of assessing the available literature it has been clear that the use of manures also has many beneficial effects. In some cases, the farmer or grower has the option of deciding whether to use farmyard manure or whether to compost the material (Table 1). It should also be acknowledged that what many farmers regard as compost is actually stacked manure; there is no way it can be regarded as compost according to the definitions listed above.

As a general summary, manures can be regarded as having higher available nutrient levels especially nitrogen and an organic component that is more susceptible to breakdown. This can make it more useful in sustaining crops that have a relatively high nutrient demand.

These are clearly generalised conclusions and would not all apply in the same situation. They nevertheless provide a useful summary of the kind of issues to be considered when planning the fertility management of a cropping rotation. The use of plant-based composts that are found in stockless systems would have more in common with the composted farmyard manure than with the stacked farmyard manure.

There is clear potential for the use of compost in organic systems to improve the overall condition of the soil, its biology and its ability to supply nutrients to the crops grown. It should not be assumed however that all composts will do the same thing and an assumption that because a material has been produced by a composting process it will be good should be avoided. Much will depend on what has been composted, how the process has been managed and the objective of the application.

An absolute key is being able to use material that is consistent in its properties (physical, chemical and biological) and is also able to provide maximum benefit to the production system. Clearly, compost produced on-farm working to a clearly-defined system such as CMC® is likely to deliver on both of these issues, although it will of course also require consistency in the feedstock. If the objective is to deliver nitrogen fertility to a demanding crop then compost of whatever kind should not be the material of choice.

Table 1: *This table has been adapted from Ott (1996) by Litterick et al. (2003) and illustrates the kind of factors that should be taken into account when considering whether to stack or fully compost available manure.*

Criteria	Composted FYM	Stacked FYM
Aim of application	Increase soil organic matter	Provide nutrients
Soil type	Sandy	Clay
Crop rotation	High proportion of legumes	Low proportion of legumes
Crop specific needs:		
Time to maturity	Long	Short
Nutrient demand	Low	High
Organic matter accumulation	Yes	No

In a mixed organic farming system where livestock enterprises are important, the use of non-composted or non-aerated materials can be appropriate especially where replacing nutrients removed by forage cuts. In most other systems, a degree of treatment including stacking should be seen as advantageous, providing steps are taken to minimise losses during the storage and breakdown phases.

Use of Compost

Advisers and producers need to look at a range of factors in the system before deciding on the most beneficial approach in the management of bulky organic materials. Soil type and basic fertility profile should both be key factors. Where the soil is light, relatively nutrient poor

and of low organic matter status, compost or fully-composted manure should be the material of choice in helping to build up the soil over the medium to long term. It may also be the case that some additional fertility in the form of stacked manure and/or proprietary materials may be required in the short term.

If working with a soil of medium to heavy texture that is well structured and has a good basic fertility profile, then the approach taken can be more flexible. In these situations, manures are likely to give the greatest benefit, though compost use should be considered in the interest of future cropping plans.

All of this must be taken in the overall context of the standards that "the fertility and the biological activity of the soil must be maintained or increased, in the first instance, by the following points:

(a) cultivation of legumes, green manures or deep-rooting plants in an appropriate multi-annual rotation programme.

(b) incorporation of livestock manures from organic livestock production in accordance with the provisions and within the restrictions of paragraph 7.1 of part B of this Annex.

(c) incorporation of other organic material, composted or not, from holdings producing according to the rules of these Standards." (Defra, 2006).

The other key aspect surrounding decisions relating to the use of compost is that of cost and there should be a commitment to examining the cost-benefit analyses of various approaches. This can be quite fraught as controlled windrow systems require high capital and running costs that may not necessarily be reflected in absolute yield increase or tangible improvements in crop quality. Supporters of such systems (e.g. CMC®) remain absolutely convinced that the production and use of such compost brings a range of benefits to the whole farming system that do not necessarily affect the bottom line, at least in the medium term.

In summary, the effectiveness of compost is closely related to its ingredients, management and consistency. Achieving that consistency through highly controlled on-farm systems may not always justify the cost of production. However, research does show that compost has the potential to improve almost all relevant soil properties and it therefore can be particularly useful for high value vegetables, fruit and protected crops.

References

IOTA PACARes Research Reviews downloadable from http://www.organicadvice.org.uk/reviews.htm

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Useful sources of further information

- International open-access archive for research papers on organic agriculture: www.orgprints.org

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[March 2009]