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Utilisation of manure composts by high-value crops: Safety and environmental challenges

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ABSTRACT

The intensification in livestock production has increased the need of efficient treatments of waste streams especially to preserve as much as possible, the nutrients into the soil-plant system. Composting is a cheap, efficient and sustainable treatment for solid wastes that is always included in any manure treatment scenario. In this paper, an overview about the environmental and safety challenges of composting of manures is made considering the compost quality requirements established by the main demanding sectors. Co-composting and additive strategies are presented as feasible options for the improvement of compost quality. For quality evaluation of manure compost, the use of both classical and innovative instrumental techniques could increase our knowledge about added properties in compost, especially those related to organic matter stability.

1. Introduction

Agricultural management is quickly changing. A new view in relation to the agricultural systems is little by little taking place, including environmental and sustainability concepts without forgetting the gross production. Several treatment approaches have incorporated compost as a key operation in advanced management systems. Moreover, it must be considered that the agricultural management through the compost use supposes a brake reduction to the greenhouse effect, with a potential C sequestration in the arid zones of approximately 0.10–0.20 tons C/ha/year for application doses of 20 Mg/ha/year (Lal, 2000). However, the development of high-quality compost from organic wastes must be focused on specific agricultural activities in order to justify the associated production cost of compost and also to obtain the compost quality demanded by each user. Several agricultural sectors could pay for high-quality composts, especially the sectors of nursery crop that uses soilless media, orchard mulching, and organic farming.

In relation to the nursery crop sector, the widely extended use of peat as growing media constituent is a concern because of the carbon reserves in peatlands are being rapidly depleted due to mining of peatland resources. Peatlands are a sink for atmospheric carbon and their carbon uptake accounts for about 12% of current human emissions. Although they are low in biodiversity, their fauna and flora are distinctive and many groups are confined to this habitat. In the EU alone, it has been estimated that 38% of the total of peatlands have been severely affected by commercial harvesting (Raeymaekers, 2000), while 3.39 million m^3 of peat is the total amount used annually by the UK horticultural industry (ODPM, 2003). For all these reasons, the British Government has proposed a very strict legislation in this aspect, with a reduction of 10% before 2010 in the use of peat as growing media and soil improver, as well as the encouragement of the re-use of organic wastes as growing media components instead of their spill. Therefore, composts can be considered as an alternative and low-cost growing media instead of peat for plant production. Usually, high-quality compost has suitable characteristics for their use in potting media, such as high hydraulic conductivity, air porosity, and stable and non-phytotoxic organic matter, and potential suppressiveness capacity against soil-borne diseases.

The use of compost in mulching is becoming a rising agricultural practice. This is because composts as mulching agents can decrease plant stress, soil-borne pests and diseases, reduce fluctuation in soil temperatures and soil erosion, provide weed suppression, and increase soil quality. In New South Wales (Australia), wide extension trials with manure compost showed savings up to 70% mineral fertilisers in the first year of mulching application (Recycled Organics Unit, 2006). In relation to this, Gonzalez and Cooperband (2002) found that combining amending and mulching management improved the yield and sustainability of field nursery production of ornamental shrub, increasing saturated

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hydraulic conductivity (K-sat) sevenfold over the non-amended control. However, their findings also showed that the compost effects on the soil physical properties depended on compost type, while the effect on shrub growth depended on the species.

Organic farming is an important agricultural activity that is practiced in almost all countries of the world, and its share of agricultural land and number of farms is growing. At the end of 2003, organic land area worldwide was estimated at about 26.5 million ha, or 69% higher than in 1998, and was managed by about 558 000 farms. With 6.3 million ha of organic area, Europe ranks second, behind Oceania (11.3 million ha), and ahead of Latin America (6.2 million ha), North America (1.5 million ha), Asia (0.7 million ha) and Africa (0.4 million ha). Europe as a whole represents more than 23% of the world organic area (European Commission, 2005). Soil-applied composts improve soil fertility mainly by increasing soil organic matter (SOM) that activates soil biota (Raviv, 2005), compost from manures being especially interesting due to its high nitrogen and phosphorus contents. Composted manure can be an alternative fertilising source in organic farming, where the use of manufactured chemicals is prohibited. For instance, Wong et al. (1999) observed a general improvement in physical properties (increase of porosity and hydraulic conductivity and decrease of bulk density), with an optimum application rate of 25–50 tons ha^{-1} of manure compost for *Brassica chinensis* and *Zea mays* L. in organic farming conditions.

2. Demanded compost: added value properties

2.1. Organic matter stabilization

Stabilisation treatments are carried out in order to improve the biological transformation of the organic matter, obtaining as a result a stabilised organic material and thus, avoiding potential risks to plants and soils when these products are used as organic amendments (Turkan and Ok, 2001; Cambardella et al., 2003). Composting is a stabilisation method currently used for manure waste management. However, the composting process must be environmentally friendly and the compost value can be also increased by incorporating additional properties, such as balanced nutrient composition, suitable physical properties, suppressive effect against phytopathogens, good degree of humification, etc. Therefore, co-composting of residual wastes with manures could be a feasible option where the incorporation of some residual material that, even though being quantitatively of little importance in the mixture, provides it properties of interest, such as nutrients, pH correction or suppressive effects. For example, the use of vinasse from the process of winery-waste distillation as a water supply for composting, significantly increase the K content in a farmyard manure pile (Bustamante, 2007) (Fig. 1).

2.2. Nutrient conservation

The use of high C/N additives with manures in composting could lead a significant reduction of N losses to atmosphere. Raviv et al. (2004) observed decreasing N losses in composting of separated cow manure using grape marc, orange peels and wheat straw, of 18%, 5% and 2%, respectively. In addition, the incorporation of phosphogypsum reduces total N loss from cattle manure composting (Larney and Hao, 2008). Moreover, the use of animal manures as ingredient in the co-composting with ligneous materials can improve compost quality (Raviv, 2005).

Another novel aspect is the use of manganese oxides as conductive elements to improve the polymerisation–humification processes and, therefore, obtaining organic products more inert to biodegradation. Luther et al. (1997) observed that the oxides of Mn^{3+} and Mn^{4+} can oxidize the organic bindings more rapidly than O_2, starting the formation of re-assembled polymers.

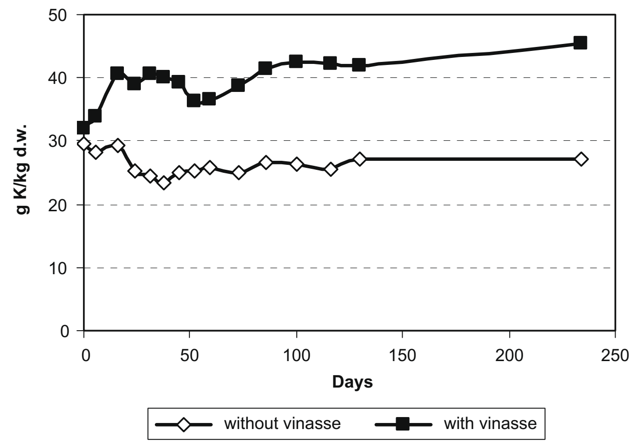

Fig. 1. Effect of the addition of vinasse as water supply in farmyard manure composting.

In addition, development of new strategies for manure composting is needed, taking into account new sources of agricultural wastes. Digestate from biogas production of manures is a new material susceptible of being composted, and could be used in organic farming in EU (Commission Regulation (EC) No. 436/2001 of 2 March 2001, that corrects the Annex II of the Council Regulation (EEC) No. 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs). Several alternatives to increase compost value using additives according to organic farming requirements can be considered: the use of urea or manure to obtain a nitrogen enrichment, phosphogypsum, natural phosphates or manure to enrich the compost in phosphorus, Fe or Mn oxides to enhance the polymerisation, as well as the use of native sulphur to acidify or calcium hydroxide, calcium oxide or manure to alkalinize.

2.3. Improved physical and chemical properties of composts

As it has been previously commented, composts may have physical, physico-chemical, and chemical properties similar to peat that make them suitable as peat substitutes (Sánchez-Monedero et al., 2004). Different organic materials, such as bark, town refuse, sawdust, sewage sludge or spent mushroom compost have been introduced as peat substitutes in potting media after proper composting (Raviv et al., 1986; Chen et al., 1988). Numerous studies have demonstrated that organic residues, after composting, can be used with very good results as growth media instead of peat (Benito et al., 2005; Pérez-Murcia et al., 2006). Bachman and Metzger (2007) studied the changes on the physical and chemical properties in potting substrate when vermicompost from pig and beef cattle manure were used, observing increases in the dry bulk density and the water-holding capacity, as well as in the different macro and micronutrient contents. In relation to this aspect, manure could have a significant role in co-composting due to its high levels of nitrogen, phosphorus, and exchange cations (Ca, Mg) that could be useful in acidification control.

In addition, compost application can also enhance several beneficial properties in amended soils, at a physico-chemical, chemical, and biological level. Campitelli and Ceppi (2008) observed that the contribution of humic acids (HA) from composted materials to soil cation exchange capacity and soil buffer capacity seems to be larger than that from the HA isolated from vermicomposting treatments.