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Composting and the potential value of compost in Mediterranean soils

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Introduction

Considering the degradation of soils and the low levels of organic matter in most Mediterranean countries there is a real need to conduct research on the feasibility of short- and long-term use in agri-, horti and viticulture of a wide variety of farm, industrial and societal waste products. Increasing soil organic matter (SOM) is crucial to improve the physical, chemical and biological soil fertility, in order to sustain food production and life on Earth. One of the most promising alternatives of conventional farmyard manure application is the use of various types of composts and other organic inputs to the soils with low organic contents. Compost is the humus resulting from the controlled biological decomposition of organic material. A wide range of materials may be composted, but they must consist of principally organic components (i.e. carbon-containing remnants or residues of life processes). Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material.

When applying the composted materials, the challenge is to know the composition and its characteristics, so as to understand and use it most efficiently. Research should therefore focus on the contribution of these organic management practices on nutrient supply versus carbon sequestration, water holding capacity, potential to reduce erosion and its main impact on soil fertility.

Source, composition and characteristics of composts

On-farm composting of agricultural feedstock's (crop residues, manures, other organic waste products…etc.) is an important source of organic matter for agricultural and horticultural farms, especially for organic farms. However, other composts from outside the farm can be also used, such as the specific industrial food waste and several domestic waste products. Agricultural use of composts from sources outside agriculture and other composts from various sources should be investigated both for short- and

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long-term use, due to the known bioaccumulation of heavy metals and other toxic elements or molecules, particularly on a long-term basis.

Composts vary greatly in their composition, degree of stabilization and ability to release nutrients for plants. Nevertheless, to successfully manage the cycle of nutrients in the soil it is necessary to estimate compost mineralization rates and the influence that composts exert on soil processes and properties. A limiting factor in the use of excessive amounts of composts, particularly when they are not completely matured, could be toxicity, the potential of pathogen microorganisms, high contents of salts or ammonia, or soil nitrogen immobilization.

Although there is a need to increase SOM content and soil carbon sequestration in the long-term to protect the agricultural soil and for other environmental reasons, compost/materials that may act as short-term sources of nutrients for fast growing crops may also be required to improve crop yields, for economic reasons. However, the pattern of nutrient release from organic materials and composts is still unclear and must be investigated to understand the contribution of compost to match nutrient availability with crop demand, for distinct composts and environmental conditions.

Initial compost materials

The following (on farm) biomasses, as initial compost materials should be relevant for organic farms in the Mediterranean areas:

- Cow, horse, goat and sheep manure, pig slurry, poultry litter
- Cereal straw, leaves and branches (pruning residues) of olive trees, vineyards and other tree crops
- residues of olives and grape pressing and processing
- waste of fruit and vegetable processing (tomato sauce, fruit juices, jams, etc.)
- slaughter house residues
- household waste water…etc.

Other materials:

- egg-shells (calcium-source)
- plant-material from the maintenance of gardens (grass and pruning residues)
- plant-material from the cleaning and maintenance of the forest (shrubs and trees)
- fruit and vegetable waste from the retail and the catering sectors

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- paper wastes
- ashes
- etc.

Nitrogen supply and other nutrients from composts

Soil nitrogen (N) supply from composts depends on the initial availability of inorganic N in the compost, the easily mineralizable N from the labile pool of compost and the longer-term rate of organic N mineralization of more recalcitrant compounds. The mature compost with high level of stabilisation may be a poor short-term source of N from mineralised organic N. However, mature composts where ammonia nitrification occurred may have nitrate-N that is immediately available for crop uptake. In contrast, immature compost may have high ammonia content but this is not beneficial for seed germination or root growth.

Quantifying nutrients becoming available from composts during the first growing season is important, but residual nutrient (particularly N) effects the year after the compost application, is also important to develop N recommendations for compost use. When applying compost the challenges are to know its composition and to understand how to use it most efficiently.
Nutrients are usually increasing proportionally during organic matter mineralisation, enriching the compost as an agricultural nutrient source. Nitrogen concentrations also increase to a degree, but are much more dynamic and losses are difficult to be actively controlled, because N is amongst the most labile nutrients. Therefore, the challenge is to keep N loss to a minimum throughout the composting process, for agronomic reasons and also to minimise environmental impacts, and to minimize N loss during and after compost application.

Composting technologies and control systems have reached an advanced stage of development, but these are too complex and expensive for most agricultural practitioners for treating, for example, livestock slurries. The development of simple, but robust and cost-effective techniques for composting animal manures and slurries is therefore required to realise the potential benefits of waste sanitation and soil improvement, associated with composted livestock manures and to produce safe, effective soil conditioning and fertilizer products.

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The nutrient content of some wastes of agricultural origin and of the municipal sewage sludge are shown in table 1 and table 2 and the potential pathogen microorganisms in solid municipal wastes is presented in table 3.

Table 1. Nutrient concentration of some wastes of agricultural origin.

Agricultural wastes	Nitrogen N (% DW)	Phosphorus P (% DW)	Potassium K (% DW)	Organic matter OM (% DW)
Sewage sludge	5	2,6	0,6	50
Fruit digested wastes	1,6	0,4	0,9	90
Beer digested wastes	3,9	0,7	1	45
Composts	1,6	0,4	1	45
Biogas-digestive solids	1,2	0,4	0,6	38
Animal bone-solids	5,5	7,6	0,2	n.a.
Pig-manure	10,5	2,5	5,8	n.a.
Cow-manure	4,7	0,9	4	n.a.
Farmyard-manure	2,6	1,2	3,4	n.a.
Mono-ammonium-phosphate	11	23,8	0	n.a.
NPK-fertilizers(15/15/15)	15	6,6	12,5	n.a.

n.a.= not applicable.

Table 2. Some characteristics of municipal sewage sludge (%), as potential and valuable compost materials.

Parameters (%)	Digested liquid sludge	Dried sludge
Dry matter weight (DW)	1-10	19-31
Organic matter (OM)	33-79	43-53
Total nitrogen (N)	1,9-6,3	2,6-3,8
Total phosphorus (P)	1,2-3,1	0,9-2,0
Total potassium (K)	0,4-0,6	0,1-0,6

Table 3. Potential pathogen microorganisms in solid municipal wastes (in 1 g DW).

Potential pathogen microorganisms	Abundance of microbes (CFU.g^{-1})	
	Sewage sludge	Solid municipial waste
Escherichia coli	10^4 - 10^7	0 - 10^9
Mycobacterium spp.	0 – 3 x 10^3	120 - 5 x 10^4
Salmonella spp.	0 - 10^5	0 - 10^4
Enterococci	10^1-10^8	10^8 - 10^9

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Solutions/possibilities/opportunities with composting

The physicochemical properties of manures may be suitable for composting treatment directly without additional interventions, such as the use of bulking agents or frequent pile turning as aeration strategies that increase the cost and complexity reducing the practicability of on-farm composting.

The separation of liquid and solid fractions of livestock slurry can be advantageous to produce nutrient-rich organic solids and potentially reduce the nutrient and organic matter contents in the liquid phase. The solids may be further processed by composting to improve the suitability and acceptability of the slurry solid fraction for use on agricultural land. This is particularly important for cattle slurry management on dairy farms where land availability for slurry application may be limited because composts can be exported to other farms with a high demand for organic amendments.

Acacia species in composts

Concerning new feedstock materials for composting, recently it was investigated the application of simplified, large scale commercial composting techniques for the treatment of waste biomass from the control of invasive *Acacia* species. The research examined the feasibility of this management approach to determine whether *Acacia* waste biomass, which is available in large quantities, was suitable as a feedstock for composting and for the production of valuable end-products such as soil improvers and substrate components.

The research has demonstrated that waste *Acacia* biomass is indeed suitable as a single feedstock input for composting – it has sufficient biodegradability and structure for effective treatment in large scale composting piles, without additional materials and with minimal management interventions. A two-component, first-order exponential model described the organic matter mineralization of *Acacia* spp. biomass, and showed that the pool sizes for labile and recalcitrant OM were similar. The pools corresponded with the rapid mineralization of more labile leafy material in a primary pool and a secondary pool of more recalcitrant branchy materials.

Stakeholders and composting

Concerning nutrient recycling of waste products from the food chain beyond the farm gate, stakeholders from many parts of the society, e.g. municipalities, biowaste plants and pulp industry need to be involved, not only from the agricultural and food sector. This means recycling of quality nutrient sources from agriculture, industry and also society, which needs improved techniques and information systems in order to have the right knowledge available for stakeholders involved.

Closing nutrient cycles at the appropriate level is an increasingly important challenge. Research should focus on quality and availability of the nutrients from recycled waste, of various origins and evaluated in terms of its sustainable use on-farm. Combination of wastes from organic sources, recycling for instance from retail and supermarkets is an area becoming more important since the amount of wastes produced is still increasing.

Research on sustainable and resource efficient solutions for recycling systems of urban organic residues are important. Farm specialisation requires appropriate options for closing nutrient cycles at local or regional scales. As the number of mixed farms tends to decrease, regional options should be developed.

Suggestions for further research items in composting

- measure the physicochemical transformations of the composting biomass
- model the OM degradation kinetics
- assess the effects of turning frequency
- determine compost sanitation temperatures to pathogen control
- determine weed seed destruction in composts
- minimize N losses and study the mobilization of other nutrients
- study the effect of organic/inorganic ratio in compost qualities
- compare the compost values of different (industrial, municipal…etc.) origins
- assess the abundance of various microbes during the composting
- study the development of simple compost quality indicators
- economical evaluation/comparison of different types of compost and organic soil amendments

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