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Composting: The way for a sustainable agriculture☆

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ABSTRACT

Compost, as stabilized organic matter, can be virtuously used for the recovery of degraded soils and their fertility restoring, carbon sequestration in the soil and the reduction in the use of chemical inputs (fertilizers, pesticides, fuel) resulting in the decrease of production costs and negative environmental impacts. Additionally, compost can be successfully used in other productive (nursery) and landscape-environmental-hobby activities (green areas, recovery of waste dumps, gardening, etc.). Choosing the most appropriate composting technology depends on some farm evaluations (volumes of materials to be composted, matrixes type and their supply places, machinery/facilities already present in the farm) and preliminary analyses of environmental and economic sustainability to be performed by means of methodologies such as Life Cycle Assessment, Life Cycle Costing and Energy Analysis.

This article briefly describes the on-farm composting technologies, available today, and reports the results of the environmental, energy and economic sustainability analysis of 5 composting plants using different composting technologies and starting matrices (bulking agents and compostable materials). These plants were built within some National and European researches and transfer projects in Basilicata and Campania regions.

Generally, on-farm composting resulted as a strategic technology for the sustainability of agricultural activities that can thus solve critical issues such as the disposal of crop residues and livestock wastes. From our results, obtained under different logistic and farming conditions, on-farm composting seems to be the most sustainable solution – from economic and environmental point of views – if compared to the ordinary agricultural waste disposal methods. In perspective, it is recommended the creation of wide farm networks for the optimization of all steps of the composting chain.

1. Composting and its benefits

Composting is "the controlled aerobic biological decomposition of organic matter into a stable, humus-like product called compost. It is essentially the same process as natural decomposition except that it is enhanced and accelerated by mixing organic wastes with other ingredients to optimize microbial growth" (USDA, 2000) (Fig. 1). Therefore, such waste management system turns a waste into a resource by creating a recycled product made up of stabilized organic matter, carbon rich and free of most pathogens and weed seeds (Alberta, 2005). Crop residues produced under greenhouse/tunnel, manure from cattle farms, agro-industrial processing residues, as well as any unsold agricultural products, can be excellent matrices to be composted. Generally, those residues are easily degradable and they have nutritional and fertilizing properties; therefore, less-compressible material with beneficial structuring function such as pruning residues, wood chips, straw (called bulking materials), should always be added for a correct composting process. Those materials can give porosity to the mass and ensure the opportune oxygen passage for aerobic microorganisms activity.

The compost can be successfully applied to the soil, with amending and fertilizing function, to recover degraded soils or maintain/increase soil fertility *sensu latu*; to exert plant disease suppressiveness; to sequester carbon into the soil thus reducing global warming; to reduce production costs and negative impacts of agricultural activities by limiting inputs of fertilizers, pesticides, and fuel (Celano, 2013; Crnko et al., 1992; Favoino and Hogg, 2008; Martínez-Blanco et al., 2009; Movahedi Naeini and Cook, 2000; Pane et al., 2016, 2013; Scotti et al.,

☆ Music while reading. Jethro Tull – Aqualung: https://www.youtube.com/watch?v=u1xY7Heaqg8c.

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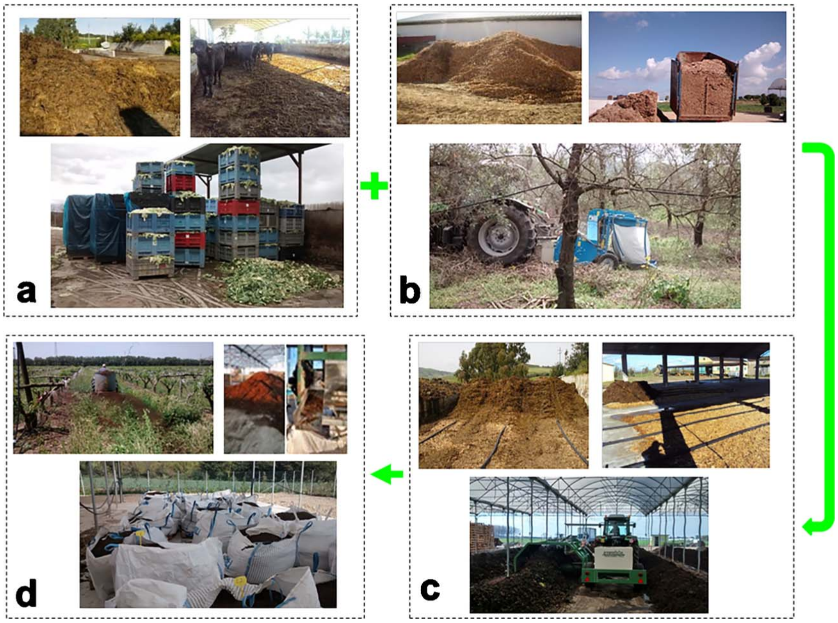

Fig. 1. A general schematization of the composting process. a) Cow-buffalo manure; agricultural crop residues. b) Bulking agent: wood chip from Short Rotation Forestry (SRF); straw or pruning residues. c) Under wet and aerobic conditions using different on-farm low technologies. d) Compost: a recycled product, generally rich in carbon and free of most pathogens and weed seeds – suitable in agriculture.

2016; Sánchez et al., 2017; Vázquez and Soto, 2017). In addition, compost can be used as a nursery cultivation substrate or as a mulching material. It is also promising its use in non-strictly productive sectors such as landscaping, environmental and hobbistic activities, public park and garden management, green recreational and sports areas, restoration of abandoned quarries and landfills, and home gardening.

Composting can be considered a C-based system, similar to reforestation, agricultural management practices, or other waste management industries and is one of the most frequently alternatives to landfill (Brown et al., 2008; Quirós et al., 2014). In addition, composting decreases environmental problems related to wastes management by decreasing waste volumes and by killing potentially dangerous organisms.

The on-farm composting process correspond to the recent provision and indication of European Commission on recycling of agricultural biomasses for organic based fertilizer in soil organic matter management, which are assumed to represent an important contribution and valuable opportunity to improve the circular economy at regional and local scale (European Commission, 2017). The agricultural utilization of compost could meet the target objective of European Union countries to decrease the quantity of organic waste going to landfill sites by 20% by 2010, and by 50% by 2050 (European Commission, 1999).

2. The on-farm composting technologies

All the composting technologies are based on three main phases: mixture preparation, bio-oxidative phase, and maturation phase. The difference between composting technologies lies mainly in the mode of running the bio-oxidative phase and so they involve different technical-economic management choices. Among the many technologies available for the bio-oxidative phase, there are:

2.1. Passive composting in windrow or pile

It involves the formation of the mix of raw material into a pile or windrow, periodically turned primarily to rebuild the porosity. Aeration is accomplished through the passive movement of air through the pile. So, this requires that the pile/windrow should be small enough to allow for this passive air movement (USDA, 2000). It is very cheap and recommended for small farms that do not have big space problems.

2.2. Composting in static windrow with active aeration

This is useful mostly for the swiftness of the composting time and for the limited space required; it uses blowers to blow air into the pile using positive pressure to provide oxygen and cooling. Blowers can be run continuously or at intervals. This composting technique requires a base layer made of porous material (wood chips or straw) to distribute air evenly either as it enters or leaves the aeration pipes, and a top layer (finished compost or sawdust) to absorb odours, deter flies, and retain moisture, ammonia, and heat (USDA, 2000).

2.3. Composting in confined systems

It can be done in wooden bins, unused storage bins, or some other appropriate vessel either with or without a roof; silo or rotating tube. Such technology is not very common in the agro-industrial sector due to the high costs of the initial investment and the *in itinere* management, making it suitable only when dealing with large quantities of compostable material.

3. Choosing the composting technology: LCA, EA, and LCC methodologies

Choosing the most appropriate composting technology depends on some farm evaluations (volumes of materials to be composted, matrixes type and their supply places, machinery/facilities already present in the farm) and on preliminary analyses of the environmental and economic sustainability of the whole process to be performed by means of methodologies such as Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Energy Analysis (EA).

LCA is an internationally recognised methodology, developed since the 1970s, which analyses environmental impacts associated with the production of a product or service throughout its life cycle or "from cradle to grave": from the extraction of raw materials, through all