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Corroboration for the successful application of humified olive mill waste compost in soilless cultivation of strawberry

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A B S T R A C T

The findings presented in this paper have shown conclusively that composted olive mill waste (COMW), characterized by its relatively high humus content, contributed to producing an economically sustainable and fit-for-purpose growing medium for soilless cultivation of strawberries. In so doing, it has also shown to be a successful replacement for the commonly used and expensive peat moss. The capacity of COMW to transport nutrients essential for the growth of different varieties of strawberries was indicated by the optimum levels of nutrients such as N, K, Ca, Mg, Na, Fe, Mn, Zn and Cu recorded in petioles and leaf blades. The relatively high amount of nutrients left over in the substrate at the end of cultivation meant that it can be recycled as organic matter in different agricultural practices.

1. Introduction

Sustainable farming practices include remediation and recycling of agricultural waste materials. Literature shows several examples of successful application of recycled organic waste in horticulture (Ribeiro et al., 2000; Baran et al., 2001). Compost made from plant crop wastes have been used in the past as peat substitute in nursery cultivation (Bugbee, 2002; Papafotiou et al., 2004; Benito et al., 2005; Raviv et al., 2005; Grigatti et al., 2007; Caballero et al., 2009). Peat is the most widely used substrate for potted plant production in nurseries and accounts for a significant portion of the materials used (Abad et al., 2001). However, peat is expensive and the future availability of peat is uncertain due mainly to concerns regarding the preservation of peat bogs.

The process used in the extraction of olive oil results in relatively large amounts of solid waste (Olive Mill Waste – OMW) depending on the technology used by the olive mill. OMW is high in organic matter and appears to lend itself to bioremediation and as a suitable substitute for peat in soil-less cultivation (Altieri et al., 2010, 2011). The recycling of OMW also affords the opportunity to achieve environmental sustainability in olive cultivation practices.

OMW is characterised by phytotoxicity, hydrophobicity, salinity, low pH, phenolic compounds and short and long chain fatty acids (Niaounakis and Halvadakis, 2006). OMW has been, and continue to be, spread on farm lands causing major environmental problems such as bio-toxicity to soil micro and macro flora (Di Bene et al., 2013), leaching effluents with high organic load into surface and ground water, soil mineralization as a result of priming effect (Guenet et al., 2010). There does not appear to be an efficient OMW management strategy that is universally practiced by the olive industry. Therefore, methods to transform OMW into value-added products have received increasing attention (Felipó, 1996; Sequi, 1996). The Istituto per i Sistemi Agricoli e Forestali del Mediterraneo, Consiglio Nazionale delle Ricerche (ISAFoM-CNR) recently developed a new technology named MATReFO (patent # WO/082814, 2005) which has the capacity to convert raw OMW into a non-leaching and non-odorous organic matter useful for agronomic applications. The MATReFO technology involves briefly mixing destoned (removal of seeds) olive husk (raw OMW) with hygroscopic additives such as cereal straw, wool waste, sawdust,

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olive leaves and twigs and olive pruning residues. This mixture with a moisture content of approximately 65% is immediately packaged in net bags and undergoes a short period of aerobic storage and maturation resulting in a humified organic matter (composted olive mill waste – COMW). The COMW has been widely experimented as soil amendment in olive orchards and short term crops such as tomato and lettuce; these trials have resulted in significant increases in plant growth (Altieri and Esposito, 2008, 2010b). COMW was also tested successfully as an ingredient in the preparation of substrate for the cultivation of the common mushroom *Agaricus bisporus* on a commercial-scale (Altieri et al., 2009;; Parati et al., 2011).

In a preliminary study, Altieri et al. (2010) evaluated also the suitability of COMW as growth media for strawberry soilless cultivation. Using COMW at the rate of 0, 25, 50, 75% (v/v) as peat substitute in fertigated (standard) and unfertigated conditions, it was shown that COMW cannot adequately replace peat when used at 75%, since it significantly reduced strawberry production and plant growth. The authors also observed that the nutrient supply provided by COMW was insufficient in achieving adequate yield in the unfertigated plots. It was therefore thought worthwhile to test the adequacy of COMW as a peat substitute for soilless cultivation of different varieties of strawberries.

2. Materials and methods

2.1. OMW

OMW was collected from the olive mill Cooperativa Nuova Cilento, S. Mauro Cilento at Salerno, Italy, where two-phase oil extraction process is used.

2.2. Preparation of compost

The MATReFO method used in the preparation of COMW for the soilless cultivation of strawberries is essentially a static composting process. The stones (seeds) were removed from the OMW using a purpose-built machine and mixed mechanically with hygroscopic organic waste in the ratio of 72% de-stoned OMW, 11% wool waste, 8.5% wheat straw and 8.5% sawdust (fresh weight basis). Net sacks were filled with this mixture and stacked on pallets protected from rain. The net sacks allowed aerobic conditions to prevail during the static composting process. The duration of the MATReFO process was three months and it resulted in the formation of COMW. The COMW was then used for all the experiments in soilless cultivation of strawberries (*Fragaria x ananassa* Duch.).

2.3. Strawberry cultivation

The trials were conducted similar to the procedures described by Altieri et al. (2010) in Martorano, Cesena (eastern Po Valley, Italy, lat. 44°10′, long. 12°15′, alt. 23 m) using cold-stored plants with crowns of 14 mm diameter (plants type A^+). The plantlets were grown in plastic trays (50 × 30 × 10 cm) under greenhouse conditions to mimic the standard soilless cultivation technique. The experimental design (Table 1) consisted of split-plots replicated three times. Three main treatments were used: 100% peat (control), 75% peat + 25% COMW and 50% peat + 50% COMW. Four varieties of strawberry (Marmolada, Irma, Patty and Maya), were used in all treatments; varieties were obtained from the experimental nursery managed by the Unità di Ricerca per la Frutticoltura, Consiglio per la Unità di Ricerca per la Frutticoltura Ricerca e la Sperimentazione in Agricoltura, located in Cesenatico (FC).

The plants were fertigated with a standard nutrient solution (stock solution diluted at 0.5–1% v/v). The standard stock solution (Table 2) was prepared using $CaNO_3$, EDTA-Fe, KNO_3, K_2SO_4, KH_2PO_4, $MgSO_4$, $MnSO_4$, $ZnSO_4$ $CuSO_4$, $Na_2B_4O_7$, Ca and Fe. They were mixed in separate tanks to prevent precipitation of salt.

Fertigation were carried out by means of a localized drip system, providing 6 applications per day with a maximum of 20–25% water leaching per application. The number of applications was based on evapotranspiration and nutrient needs of the plants during the cultivation phases.

The trials were managed according to recommendations laid down for annual commercial crops published by Regione Emilia Romagna, Italy (2009) in order to achieve the optimum growth of the plants and avoid pathogen and pest diseases.

Table 1
COMW and peat combinations (main treatment) used in strawberry soilless cultivation trial, carried out on different varieties (secondary treatment).

Main treatment	Combinations
Control	100% peat + 0% COMW
25COMW	75% peat + 25% COMW
50COMW	50% peat + 50% COMW
Secondary treatment (varieties)	
Irma	
Marmolada	
Maya	
Patty	

COMW = composted olive mill waste.

2.4. COMW analysis

Three months old COMW was collected in triplicate for chemical, physical and biological analyses (Altieri et al. (2010) Moisture content was determined as weight loss upon drying at 105 °C in an oven for 24 h. Electrical conductivity (EC) and pH were measured using water extract 1:10 (w/v). Ash content was determined on samples previously oven-dried at 105 °C and ashing at 650 °C for 24 h in a muffle furnace. Total organic content (TOC) was determined by the Springer-Klee method and total nitrogen by the Kjeldhal method, both as reported in DI.VA.P.R.A and I.P.L.A (1992). Phosphorus was measured after acid digestion and color-metering of phosphorus as molybdovanadate phosphoric acid (Murphy and Riley, 1962). Flame atomic absorption spectroscopy (Perkin Elmer, AAnalyst 200) was used to measure K, Ca, Mg, Na, Fe, Mn, Cu, Zn on samples, after digestion with concentrated HNO_3 (DI.VA.P.R.A., 1992). Water-soluble polyphenols were determined in water

Table 2
Stock solution used for fertigation during the phenological stages of growth of strawberries.

Phase		Vegetative	Productive
		Macro-nutrients	
$N-NO_3^-$	$g\ l^{-1}$	5.5	6.2
P		4.7	5.4
K		14.6	24.4
Ca		6.6	5.7
Mg		3.7	3.1
S		4.9	6.5
		Micro-nutrients	
Fe	$mg\ l^{-1}$		139.5
Mn			37.0
B			23.1
Zn			13.4
Cu			1.5

pH of the nutrient solution was adjusted at 5.5–6.2 with HNO_3 30% (v/v) and electrical conductivity was kept at 1.4 and 1.2 dS m^{-1} during vegetative and productive phases, respectively.