International Biodeterioration & Biodegradation 85 (2013) 254–259

Contents lists available at ScienceDirect

International Biodeterioration & Biodegradation

journal homepage: www.elsevier.com/locate/ibiod

Short communication

The effect of olive oil solid waste application on soil properties and growth of sunflower (*Helianthus annuus* L.) and bean (*Phaseolus vulgaris* L.)

Remzi Ilay*, Yasemin Kavdir, Ali Sümer

Çanakkale Onsekiz Mart University, Agricultural Faculty, Soil Science Department, 17020 Çanakkale, Turkey

ARTICLE INFO

Article history:
Received 29 April 2013
Received in revised form
23 July 2013
Accepted 23 July 2013
Available online 6 September 2013

Keywords:
Olive oil solid waste
Morphological properties
Macroelements
Microelements
Sunflower
Bean

ABSTRACT

Research on the reuse and recycling of agricultural by-products and industrial wastes are becoming increasingly important due to storage and environmental problems associated with these wastes. This study investigated the effect of olive oil solid waste (OSW) application rates on the macro- and micro-elemental contents and plant growth of bean (*Phaseolus vulgaris* L.) and sunflower (*Helianthus annuus* L.) and soil properties. OSW was mixed with soil at rates of 0, 3, 5 and 7% w/w. Sunflower was grown for 45 days and bean for 30 days in pots. Relative phosphorus (P), calcium (Ca), zinc (Zn) and boron (B) contents by mass of sunflower plants increased while nitrogen (N) and carbon (C) content decreased. In contrast in bean, P, B and Zn contents were increased but C, N, Ca, and manganese (Mn) contents decreased. Total carbon (TC), total nitrogen (TN) and electrical conductivity (EC) increased while pH decreased pot soils after harvesting. Direct application of OSW to clay loam soil has significant negative impacts on growth of sunflower and bean. However, soil properties were enhanced and organic matter content increased.

1. Introduction

The olive tree (*Olea europaea* L.) is characteristic of Mediterranean countries. Turkey is an important olive producer in this region. Mean annual global production of olive oil between 2005 and 2009 was 13.8×10^6 tons, with Turkey accounting for 0.7×10^6 tons, approximately 5% (FAO, 2011). Olive trees are mostly cultivated for oil extraction and for table olive production in Turkey.

Production of olive oil is one of the most traditional agricultural industries in the Mediterranean Region and is economically important (Owen et al., 2000). 98% of global olive oil production is produced from Mediterranean countries (IOOC, 2011). This olive oil extraction generates various harmful by-products. All solid by-products after oil extraction are called "Pirina" in Turkey. Waste disposal and storage of these residues and by-products is difficult, causing environmental problems such as water and soil pollution. There is therefore a need to improve appropriate management programmes and conduct research into appropriate utilization of olive solid waste.

Olive solid wastes and other organic residues can be used as green-wastes in the manufacture of composts which contribute to the sustainability of Mediterranean agro-ecosystems (Manios, 2004). Composts derived from agri-industrial wastes can be used as a soil conditioners and fertilizers in agriculture and horticulture. Extensive investigations have been undertaken into the effect of olive oil solid waste compost on plant growth. Application of olive solid waste compost enhanced corn morphological properties (Kavdir et al., 2008).

Soil organic matter is one of the major factors used for the characterization of soil quality, erosion risk and crop productivity (Stevenson, 1994; Reeves, 1997). López-Piñeiro et al. (2008) reported that application of two-phase olive mill waste on olive trees significantly increased soil organic carbon, TN, available P and K, and aggregate stability after two years, concluding that olive mill waste could be used as a source of organic matter. Application of raw olive mill waste increased olive yield. However, olive waste contains a wide range of organic pollutants (Brändli et al., 2005, 2007a, 2007b) and care must be taken before applying them to soil. There are contrasting results in the literature about the effects of direct soil application of OSW on soil properties and plant. Tejada et al. (1997) reported a negative effect on the soil structural stability while Kavdır and Killi (2008) reported positive effects of OSW application on soil aggregate stability of sandy and loamy soils.

Olive solid waste may also negatively affect seed germination, plant growth and soil microbial activity. Several studies have reported the phytotoxic and antimicrobial effects of both olive-mill

* Corresponding author. Tel.: +90 286 218 00 18x1353.
E-mail addresses: rilay@comu.edu.tr (R. Ilay), kavdirya@comu.edu.tr (Y. Kavdir), sumer@comu.edu.tr (A. Sümer).

0964-8305/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ibiod.2013.07.008

wastes and by-products due to phenol, organic and fatty acid contents (González et al., 1990; Riffaldi et al., 1993; Linares et al., 2001). Direct application of OSW reduced tomato plant growth, while OSW compost had the opposite effect (Killi, 2008). Therefore the influence of OSW on plant growth must be determined in order to assess and overcome these negative effects. The aim of this study was to determine effects of OSW application on sunflower and bean growth and soil properties.

2. Materials and methods

2.1. Applications and experimental design

Two simultaneous pot experiments were conducted in order to characterize plant responses to direct application of OSW to the soil. Soil samples were taken from 0 to 20 cm depths at Çanakkale Onsekiz Mart University Research Field Station, and sieved through a 9 mm sieve. Chemical and physical properties of soil are presented in Table 1. Olive oil solid wastes were provided from the Elta Agriculture Enterprise in Gökçeada, Çanakkale. Properties of OSW are presented in Table 2. OSW was sieved through a 6 mm sieve diameter and mixed with soil at rates of 0, 3, 5, and 7% w/w.

A randomized block design with four replicates was utilized for the experimental procedure. Four levels (0%, 3%, 5%, and 7%) of OSW application were used. Five sunflower (Syngenta Sanay variety) and five bean (Asgrow variety) seeds were sown in each pot. Plants were thinned to one plant after germination. Plant growth medium was prepared to supply optimum lightening period (12–15 h) and temperature (22–27 °C). All plants were watered regularly according to their requirements.

2.2. Methods

2.2.1. Plant morphological measurements

Sunflower was grown for 45 days and bean was grown for 30 days. The aboveground parts of plants were then cut, weighed and dried at 65 °C for 2 days. Plant height was determined using a ruler and stem thickness was determined by a digital caliper (Mitutoyo). Chlorophyll readings were measured by using Chlorophyll Meter-Spectrum CM 1000 (BRT 1) under light source (Unit 1347 pro lamb).

2.2.2. Plant and OSW chemical analyzes

2.2.2.1. Total C and N. The entire dried plants and OSW were ground with plant grinder (Yellow line, A10, IKA-Werke) then total N and C of plants and OSWs determined by using Leco TruSpec CN elemental analyzer (Kirsten, 1983).

2.2.2.2. Macro and microelement analyzes. Macro and microelement contents of OSW and plants were determined in plant dry ash. 0.5–1 g of dried plant sample was weighed into porcelain crucible then placed to muffle furnace and ashed at 550 °C for 4 h. After ashing samples were allowed to cool in desiccators for approximately 1 h. Ash was dissolved in HCl 10 ml (1 + 1) and transferred quantitatively to 100 ml volumetric flask. Diluted to final volume with distilled water. Samples analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES) (Wolf et al., 2003).

Table 1
Some chemical and physical properties of experiment soil.

EC (μS cm^{-1})	pH	N (%)	$CaCO_3$ (%)	CEC (cmol kg^{-1})	OM (%)	Texture class		
						Clay (%)	Silt (%)	Sand (%)
235	8.1	0.10	15.4	15.5	1.6	36.98 CL	31.99	31.03

OM: organic matter.
**: Values are expressed as the mean ± S.E.M (The standard error of the mean).

Table 2
pH, EC values, some macro and micronutrient contents (total) of OSW.

Parameters	Value
pH	5.7 ± 0.04[a]
EC (μS cm^{-1})	822 ± 2
N (%)	1.12 ± 0.06
P (%)	0.04 ± 0.00
K (%)	0.57 ± 0.00
Ca (%)	0.5 ± 0.02
Mg (%)	0.06 ± 0.00
B (mg kg^{-1})	16.9 ± 0.55
Fe (mg kg^{-1})	1243.91 ± 75.61
Mn (mg kg^{-1})	32.75 ± 1.99
Zn (mg kg^{-1})	17.34 ± 3.15
C (%)	49.1 ± 0.75
Total phenolic compounds (mg kg^{-1})	706.4 ± 85.8
C/N	43.8 ± 1.86

[a] Values are expressed as the mean ± S.E.M (The standard error of the mean).

2.2.3. Soil analysis

2.2.3.1. Cation exchange capacity. Cation exchange capacity was measured by saturating the exchange sites of soils with sodium, using 1 N sodium acetate with pH adjusted to 8.2. The samples were then washed twice with ethanol to remove any excess sodium. Ammonium acetate was then passed through the samples so that NH4 replaced the Na on exchange sites and Na was measured by flame photometer (Soil Survey Staff, 1996).

2.2.3.2. EC and pH measurements. Initial soil samples were sieved through a 2 mm sieve and then mixed with DI water at 1:2.5 ratio, they were then set overnight and the EC was determined using a WTC EC-meter model LF 320.

Soil pH was determined in same water-soil mixture by using an Orion 420A pH-meter.

After experiment pot soils were also sieved through a 2 mm sieve and then mixed with DI water at 1:2.5 ratio. Soil pH and EC were determined as explained above.

pH and EC of OSW were determined after mixing OSW with DI water at 1:5 ratio (TMECC 04.11).

2.2.3.3. $CaCO_3$ analyze. A Scheibler calcimeter was used to measure the $CaCO_3$ (%) is based on the volumetric analysis of the carbon dioxide, which is released during the application of hydrochloric acid solution in soils carbonates (Soil Survey Staff, 1996).

2.2.3.4. Soil texture. Soil texture was determined using the hydrometer method (Gee and Bauder, 1986).

2.2.3.5. Total phenol compounds. The total phenol content was determined colorimetrically at 750 nm, using the Folin-Ciocalteu reagent and expressed as gallic acid equivalents (Lesage-Meessen et al., 2001).

2.2.3.6. Statistical analyses. Statistical analyses were computed using Statistical Analysis System (SAS Institute, 1999).

3. Results

3.1. Effects of OSW on plant morphology

This study showed that direct application of OSW to soil inhibited both bean and sunflower growth (Tables 3 and 4). Plants height, leaf numbers, dry weight, fresh weight, stem thickness and chlorophyll meter readings of bean and sunflower were greater in control treatments than OSW treatments. Plant height of bean in