Annals of Agricultural Science (2015) 60(2), 413–421

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Annals of Agricultural Science

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Response of barley grown under saline condition to some fertilization treatments

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Received 25 October 2015; accepted 9 November 2015
Available online 22 December 2015

KEYWORDS

Barley;
Compost;
Rice straw;
OMW;
Zinc;
Salinity

Abstract Two field experiments were conducted at 2010–2011 and 2011–2012 winter seasons under the saline conditions of El-Tena plain (17,000 ppm), North Sinai, to investigate the effect of different organic fertilization sources (30 m^3 $fed.^{-1}$ of animal dung, 6 tones $fed.^{-1}$ of each of rice straw with Olive Mill Wastewater compost (OMW compost) and the regular rice straw compost (RS-compost) besides 20 m^3 $fed.^{-1}$ as the conventional dose of animal dung as the control treatment in addition to foliar application with different concentrations of zinc sulphate (0, 10, 20 and 30 ppm) on the growth, productivity, free proline content and total chlorophyll content of Giza 123 Cultivar of barley (*Hordeum vulgare* L.).

Results obtained indicated that both RS-compost and OMW-compost had positive effects on soil properties where barley growth and productivity were more than the conventional organic fertilization under saline conditions; yet, applying OMW-compost under the saline conditions should be under precautions to prevent increasing the EC of the soil.

Applying $ZnSO_4$ as a foliar application into barley plants increased the plant productivity as a result of enhancing the plant metabolism and growth. The highest results were obtained from applying 30 ppm. Free proline concentration was found to be directly proportional to higher salinity level.

For the interaction between OMW-compost and $ZnSO_4$ foliar application, the highest results except for the free proline were obtained from RS-OMW compost × 30 ppm $ZnSO_4$.

Introduction

Barley is considered as one of the most important cereal crops in Egypt. Since early history it occupied a very important position in the Egyptian cropping system for its moderate salt tolerance, and capability for growing in a wide range of environmental stresses including arid, poor or saline soils (Abd El-Hady, 2007). It also can tolerate high densities of chemical pollutants and gain an economical yield under adverse conditions (Ayman, 2015).

The olive oil production of Mediterranean countries represents ca. 98% of the entire worldwide production (Food and Agriculture Organization, 2013). Olive mill wastewater

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Peer review under responsibility of Faculty of Agriculture, Ain-Shams University.

http://dx.doi.org/10.1016/j.aoas.2015.11.002
0570-1783

(OMW) is the main waste product produced by the three-phase extraction of olive oil. The disposal and treatment of this liquid waste are the main problems of the olive oil industry because of its high organic load and content of phytotoxic and antibacterial phenolic substances, which resist biological degradation (Aktas et al., 2001). OMW has also a high potassium concentration and notable levels of nitrogen, phosphorus, calcium, magnesium, and iron (Paredes et al., 1999), which are important factors in soil fertility. However, many authors have observed negative effects on plants and soil properties when OMW is used directly as an organic fertilizer (Sierra et al., 2001; Casa et al., 2003; Cereti et al., 2004). Hence, a conditioning treatment of this waste is necessary to produce a stable and easily manageable end-product. Different methods have been proposed for OMW treatment based on evaporation ponds, thermal concentration, and different physicochemical and biological treatments (Martıinez Nieto and Garrido Hoyos, 1994). However, generally, most methods are very expensive and unable to solve the problem completely because of the need to dispose the sludge or other by-products deriving from the process.

Composting is a widely used treatment for organic wastes particularly for rice straw which induces a serious environmental problem that is known in Egypt as black clouds; thus, the composting of rice straw and OMW to obtain organic fertilizers could be an economically and ecologically acceptable way to dispose it. During the process of OMW composting, the organic matter is biodegraded mainly through exothermic aerobic reactions, producing carbon dioxide, water, mineral salts, and a stable and humified organic material. Composting experiments with OMW have been performed by different research groups (Tomati et al., 1995; Paredes et al., 1996, 2000; Vlyssides et al., 1996) who observed that OMW needed lignin–cellulosic wastes as bulking agents and other materials as a nitrogen source for its suitable composting, so that the phytotoxicity could be eliminated and a final product with stabilized and humified organic matter obtained. However, not enough data are currently available on composting process of OMW and to evaluate its effects during the composting process. The effect of OMW compost on crop production and soil properties has been studied only scarcely. Cabrera et al. (1990) observed a higher ryegrass yield with inorganic fertilizer than with OMW compost, at doses of 20 and 50 tones compost ha^{-1}, and the nutritional status of the plants, in general, was very similar in all treatments. Also, Galli et al. (1994) found that lettuce yield increased with increasing OMW compost dose, but crop production comparable to mineral fertilization was obtained only with high compost application rates (above 80 tones ha^{-1}). The biomass yields of maize fertilized with OMW compost at 60 and 90 tones ha^{-1} were, respectively, similar to and higher than those receiving inorganic fertilizer (Tomati et al., 1996). Cabrera et al. (1990) observed that OMW compost application in the soil caused positive effects on physical, chemical, and biological properties of the soil.

Zn is one of the micronutrients that play a very important role in plant metabolism particularly under stress environments including saline conditions; it had a positive effect on growth parameters, yield and yield components under water stress conditions as reported by Abd El-Hady (2007). He also suggested that Zn has a control mechanism and/or a regulatory function on the Na and Cl uptake and translocation rate. The role of Zn in this mechanism is not explained clearly; hence, Zn might possibly be involved in the integrity and function of the bio-membranes of plants as reported by Yilmaz et al. (1997).

The aim of the present work was to evaluate the effect of OMW on the composting of organic wastes including rice straw as biological tool or bioremediation of OMW and as new method for disposal of rice straw. The effect of both compost and foliar application of $ZnSO_4$ and their interactions on barley growth and productivity was also studied.

Material and methods

Two field experiments were conducted at 2010–2011 and 2011–2012 winter seasons under the saline conditions (17,000 ppm) of El-Tena plain, North Sinai, to investigate the effect of different organic fertilization sources (30 m^3 $fed.^{-1}$ of animal dung, 6 tones $fed.^{-1}$ of each of rice straw with Olive Mill Wastewater (OMW) compost and the regular rice straw compost and 20 m^3 $fed.^{-1}$ as the conventional dose of animal dung as the control treatment) in addition to foliar application with different concentrations of zinc sulphate (0, 10, 20 and 30 ppm) on the growth, productivity, free proline content and total chlorophyll content of barley.

Barley (*Hordeum vulgare* L.) Cultivar Giza 123 grains were kindly obtained from Field Crops Res. Inst., Agricultural Research Center, Giza, Egypt. Following the common agricultural practices of the region, the experimental plot area was 11.2 m^2 with eight rows of 4 m in length and 35 cm in width. Barley grains were sown on the upper third of rows, on 20 November in both seasons with seeding rate 50 kg $fed.^{-1}$.

Compost raw materials were obtained from different locations i.e., Olive Mill Wastewater (OMW) was obtained from different olive mills in El-Arish city-North Sinai Governorate, rice straw (RS) was obtained from Sharkia Governorate, and animal dung (AD) was obtained from the location. The analyses of the starting materials are shown in Table 1.

Two piles were prepared by mixing AD with RS then OMW was added to one of the piles (pile 1), and RS had similar contents of hemicellulose and lignin (approximately 33% of each) and high cellulose content (46.5%) according to European Commission (2001). The mixtures were prepared in the following proportions, on a fresh weight basis (dry weight basis in brackets):

Pile 1: 33% AD + 67% RS + 0.9 l OMW kg^{-1} (9:88:3).
Pile 2: 39% AD + 61% RS (12:88).

The mixtures (about 2000 kg each) were composted in a pilot plant in trapezoidal piles (1.5 m height with a 2 × 3 m base). The Rutgers static pile composting system was used (Finstein et al., 1985), both piles were covered with polyethylene sheet and were mixed once every 40 days for homogenizing the pile contents, the piles were matured after 120 days of incubation.

In the raw materials and the composting samples (Table 1), electrical conductivity (EC), pH, cation exchange capacity (CEC), germination index (GI), dry matter, organic matter (OM), total nitrogen (NT), C_{org}, water-soluble organic carbon (CW), 0.1 M NaOH-extractable organic carbon (CEX), fulvic acid-like carbon (CFA), humic acid-like carbon (CHA),