EFFECT OF THE IRRIGATION WITH WASTEWATER ON THE BIOCHEMICAL PROPERTIES OF AN AMENDED SOIL

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Abstract

Treated wastewaters can constitute an important resource for the irrigation of crops in combination with organic amendments. However, the knowledge about the effects of the combined use of treated wastewater and amendments is still limited. The aim of this work was to investigate the effects of the combined application of wastewater and different organic residues on C and N mineralisation and microbial biomass size and activity. A Fluventic Eutrudept soil (USDA) was irrigated at 40% of water holding capacity using distilled water or an artificial wastewater and thereafter amended (0.5% w/w) with three different organic residues: pig slurry digestate, rapeseed meal and a compost. The amended soil was then incubated for 30 days at 20 °C. During incubation, soil CO_2 evolution, K_2SO_4 extractable NH_4^+, NO_3^-, organic C and N, soil microbial biomass and some enzymatic activities were determined. Results demonstrated that the use of wastewater in combination with organic residues does not negatively affect the mineralisation process or the content and activity of soil microbial biomass. Furthermore, the wastewater provided additional nutritive elements to those added with the organic amendments.

Keywords: CO_2 emissions, Treated wastewater, Bioenergy residues, Mineralisation, Soil Microbial Biomass

INTRODUCTION

One of the major threats for the sustainability of agricultural systems is represented by the decreasing availability of water for irrigation, especially in arid and semi-arid regions. In this context, treated wastewaters can constitute an important resource, not only for irrigation, but also for the supply of organic matter and nutritive elements. This would reduce the requirements for inorganic fertilizers and decrease the costs of crop production.

Another problem faced by agricultural systems in the last decades is the loss of soil organic matter caused by the intensification of agricultural practices. An effective solution to this problem is represented by the application to soil of organic residues of different origin.

As a consequence, the simultaneous use of amendments and treated wastewaters is likely to increase in the next years. While there are many studies regarding the effect of soil application of either treated wastewater or organic residues, the knowledge about the effects of the combined use of treated wastewater and amendments is still limited. However, in order to increase the efficiency of this strategy and to minimize the possible adverse effects, a thorough evaluation of the effects of treated wastewater on amended soils is necessary.

The aim of this work was to investigate the effects of the combined application of wastewater and different organic residues on C and N mineralisation, CO_2 emissions and microbial biomass size and activity.

MATERIALS AND METHODS

Two aliquotes of a Fluventic Eutrudept (USDA) soil (pH 8.3, clay 3%, TOC 11.7%, TN 0.57%) were brought to 40% of water holding capacity using distilled water or an artificial wastewater (pH 7, TOC 643 mg L^{-1}, TN 216 mg L^{-1}, EC 1148 µS cm^{-1}) which was prepared in order to reproduce the chemical composition of the wastewater used by Meli *et al.* (2002). The aliquots of the moist soil were amended (0.5% w/w) with 3 different organic residues: pig slurry digestate (37.9% TOC, 4.4% TN), rapeseed meal from biodiesel production (45.9% TOC, 6.0% TN) and household waste compost (34.4% TOC, 2.3% TN) and thereafter incubated in the laboratory for 30 d at 20 °C.

During incubation, soil CO_2 evolution was continuously measured every 6 hours by means of an automated system for continuous gas sampling and analysis (Mondini *et al.*, 2010), while aliquots of soils were taken after 2, 7 and 30 days of incubation for analysis of extractable NH_4^+, NO_3^-, organic C (EOC) and N (EN) and some enzymatic activities. Soil microbial biomass was also analysed after 2 and 30 days of incubation. Extractable NH_4^+, NO_3^-, EOC and EN were determined in a 1:4 (w/v) K_2SO_4 0.5M extract. Extractable NH_4^+ was determined by a modified colorimetric method based on Berthelot's reaction. The content of NO_3^- was measured by reading the absorbance at 220 nm and subtracting the absorbance at 275 nm. EOC and EN were measured using a TOC-VCSN analyser (Shimadzu). Soil microbial biomass C (B_C) was determined by the fumigation-extraction method (Vance *et al.*, 1987). The different enzymatic activities were measured in soil extracts utilizing a fluorescence method.

RESULTS AND DISCUSSION

CO_2 dynamics

Dynamics and amount of soil CO_2 evolution were greatly affected by the different residues (Figure 1). The highest emissions were obtained with rapeseed meal. The addition of the wastewater provoked a slight increase on the CO_2 emissions for all the residues during the first 10 days of incubation.

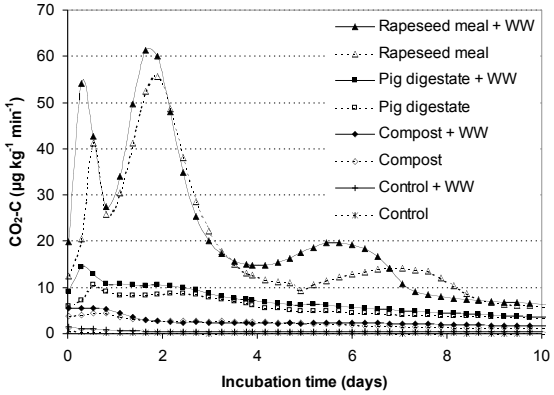

Figure 1. CO_2 emissions during the first 10 days of incubation of soil amended and non amended, irrigated and non irrigated with wastewater.

Cumulative extra CO_2–C (difference in cumulative respiration between amended and control soil) ranged from 2.6 to 14.7% of the C added with the residues (Table 1). The addition of wastewater provoked an increase in cumulative respiration in all the treatments, which was higher with rapeseed meal (37.2 µg CO_2–C g^{-1}). Moreover, the utilization of wastewater caused a *priming effect* in soil amended with rapeseed meal and pig digestate, likely caused by the readily biodegradable organic compounds added with the wastewater.

Table 1. Extra CO_2–C and Net mineral N in the amended and non amended soil irrigated and non irrigated with wastewater.

Residue	Extra CO_2–C		Net mineral N	
	(µg g^{-1})	(% of added C)	(µg g^{-1})	(% of added N)
Rapeseed meal	337.5	14.7	134.9	38.5
Rapeseed meal + WW	374.7	15.6	157.3	40.8
Pig digestate	122.9	6.5	46.0	17.9
Pig digestate + WW	135.7	6.8	75.8	25.9
Compost	44.1	2.6	-8.4	-6.2
Compost + WW	50.8	2.8	16.4	9.6
Control + WW	7.6	7.2	24.6	69.4

Net (control subtracted) mineral N (NO_3^- + NH_4^+) at the end of the experiment increased in the soil amended with all the residues except for the compost which led to N immobilization. Due to the N contained in the wastewater, its addition to the soil increased the net mineral N.

Soil Microbial Biomass and Enzymatic Activity

Soil amendment with organic residues caused a general increase of B_C (Figure 2a), but with significant differences among them (rapeseed meal > pig digestate > compost). Particularly relevant was the increase in the B_C recorded in the soil amended with rapeseed meal after 2 days of incubation. Addition of wastewater did not cause significant variations in the soil microbial content.

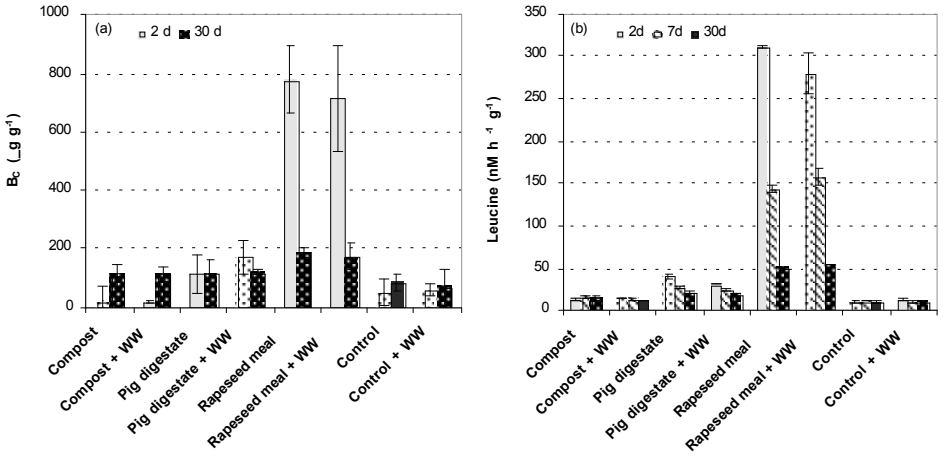

Figure 2. Microbial biomass C after 2 and 30 days of incubation (a) and leucine aminopeptidase activity after 2, 7 and 30 days of incubation (b).

Figure 2b reports the values of Leucine aminopeptidase activity in amended soil as an example of the typical response of the measured enzymatic activities. As for B_C, soil amendment caused a general increase in enzymatic activity that was higher in soil amended with rapeseed meal, a residue characterized by a high amount of readily available soluble organic C (data not shown). Addition of wastewater did not significantly affect the enzymatic activity.

CONCLUSIONS

This study clearly indicates that the application of wastewater to an amended soil may increase the mineralisation process and the content and activity of soil microbial biomass. Furthermore, the wastewater provides additional nutritive elements to the nutrients added with the organic amendments. In the case of the soil amended with rapeseed meal and pig digestate the addition of wastewater stimulated soil organic matter mineralisation (endogenous and/or exogenous), with benefits related to the release of nutritive elements and the availability of readily degradable substrates for the microbial biomass. Therefore, the use of wastewater for irrigation of amended soils appears as an optimum strategy for the recovery of treated wastewaters.

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