Program Short-term mobility-Anno 2011. Soggiorno di ricerca della Dr.ssa Maria Angeles Bustamante Muñoz: Report of the results obtained

Main objective

This research stay is integrated within a research project to evaluate the efficiency of the use of organic amendments as a method of recovering degraded soils in semiarid regions. The experiment established is based on the study of the effects of the incorporation into a semiarid soil from central Italy of two composts elaborated using the solid fraction of two digestates (obtained after the anaerobic digestion of cattle and pig slurry, respectively) at different rates (30 t/ha and 60 t/ha), compared with a control treatment (the unamended soil) and a mineral fertilised soil. Additionally, in these soils, rosemary (*Rosmarinus officinalis*) plants were planted.

The purposes of this research stay were to study the initial effect of the treatments assayed on the soil biological activity and C pool conservation. For this, a complete characterisation of the soil and of the organic materials has been carried out, as well as, chemical and, especially, microbiological parameters, such as soil respiration and microbial biomass, indicators of the soil microbial activity, has been determined in the initial samples.

Experimental design

During the visit of Dr. Bustamante, within the context of the project previously commented, has been carried out the characterisation of the soil and compost samples and the determinations of the pH, soil respiration and soil microbial biomass C in the initial samples corresponding to the 6 scenarios established in the experiment: S1 (control soil); S2 (soil + mineral fertilisation); S3 (soil + compost elaborated with cattle manure anaerobic digestate (dose 1: 30 t /ha)); S4 (soil + compost elaborated with cattle manure anaerobic digestate (dose 2: 60 t/ha)); S5 (soil + compost elaborated with pig slurry anaerobic digestate (dose 1: 30 t/ha)); S6 (soil + compost elaborated with pig slurry anaerobic digestate (dose 2: 60 t/ha)). Soil respiration was determined according to the methods of Stotzky (1965) and Anderson (1982), while microbial biomass was measured by the chloroform fumigation-extraction method described by Vance et al. (1987).

Figure 1. Detail of the experimental plot.

Results obtained

The results showed in this report are the initial results obtained during the research stay of Dr. Bustamante and corresponding to the initial stage of the project previously commented.

In table 1 are shown the main characteristics of the soil and of the organic materials used in the experiment. The soil used in the experiment is a loam textured soil, with an alkaline character, low salinity and very low contents in total organic carbon and in organic matter, these contents being lower than 1%, considering the soil used as semiarid. On the other hand, the composts used showed high contents in organic matter and total nitrogen, showing compost 2 the greatest N concentrations. Also, these composts showed pH values close to neutrality and notable values of the electrical conductivity.

Table 1. Main characteristics of the soil and composts used.

Parameter	Soil	Compost 1	Compost 2
pH	**8.33**	**6.88**	**6.53**
Electrical conductivity (dS/m)	**0.092**	**6.19**	**5.11**
Soil texture	**Loam**	**--**	**--**
% Sand	**43**	**--**	**--**
% Silt	**41**	**--**	**--**
% Clay	**15**	**--**	**--**
Organic matter (%)	**0.74**	**70.2**	**67.6**
Total organic C (%)	**0.49**	**34.6**	**34.5**
Total N (%)	**0.15**	**2.90**	**3.03**
C/N	**3.28**	**11.9**	**11.4**

Although the incorporation of the treatments S3 (compost 1 at the dose 30t/ha) and S6 (compost 2 at the dose 60 t/ha) to the soil resulted in a slight decrease in soil pH immediately after amendment (Fig. 2), this decrease was not significant probably due to the buffering effect of the alkaline and calcareous soil.

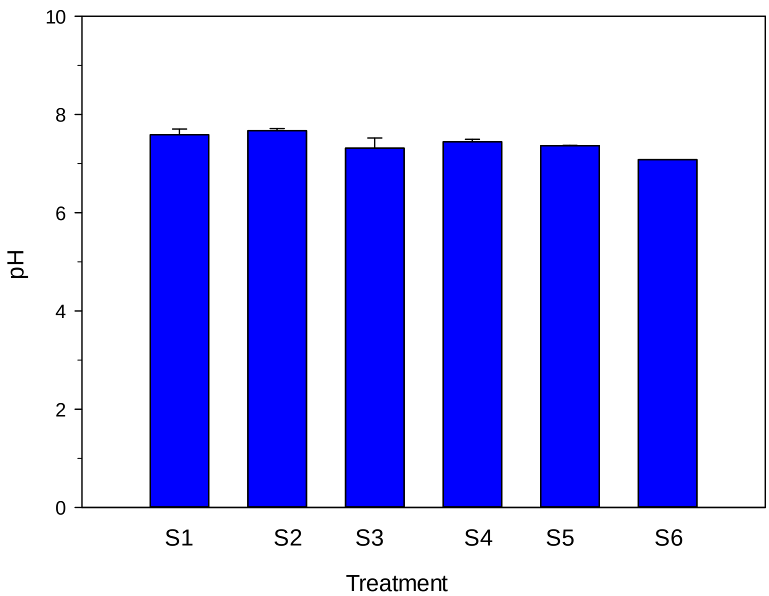

Figure 2. pH values of the soils treated at the beginning of the experiment. S1 (control soil); S2 (soil + mineral fertilisation); S3 (soil + compost of cattle manure anaerobic digestate (dose 1:30 t /ha)); S4 (soil + compost of cattle manure anaerobic digestate (dose 2: 60 t/ha)); S5 (soil + compost of pig slurry anaerobic digestate (dose 1: 30 t/ha)); S6 (soil + compost of pig slurry anaerobic digestate (dose 2: 60 t/ha)).

Therefore, initially, the incorporation of the organic amendments did not suppose a significant change in the pH values of the soil compared with the unamended soil and with the soil with mineral fertilisation.

Figure 3 shows the values of the soil respiration in the initial amended and not amended soil samples. On the contrary with respect to the pH values, soil respiration values were different between treatments, showing the soil with the mineral fertilisation (S2) the greatest values of this parameter, together with the treatment with compost 1 at the low dose (S3), compared with the control soil.

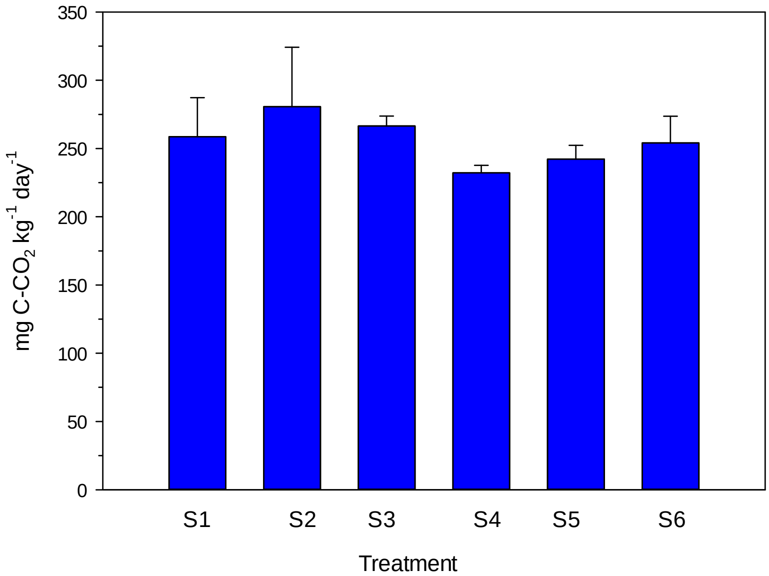

Figure 3. Soil respiration of the soils treated at the beginning of the experiment. S1 (control soil); S2 (soil + mineral fertilisation); S3 (soil + compost of cattle manure anaerobic digestate (dose 1:30 t /ha)); S4 (soil + compost of cattle manure anaerobic digestate (dose 2: 60 t/ha)); S5 (soil + compost of pig slurry anaerobic digestate (dose 1: 30 t/ha)); S6 (soil + compost of pig slurry anaerobic digestate (dose 2: 60 t/ha)).

The rest of treatments showed values of the soil respiration similar or even lower than those observed in the control soil. This fact could be due to the presence of easy-available nutrients in the treatment with inorganic fertilisation, which could have enhanced initially the activity of the microorganisms.

In the Figure 4 is shown the values of the soil microbial biomass in the soils studied at the beginning of the experiment. This parameter showed the greatest differences between the treatments assayed. The treatments S4, S5 an S6, corresponding to the application of compost 1 (from cattle manure anaerobc digestate) in high dose and compost 2 (from pig slurry anaerobic digestate) in both doses, showed the highest values of the soil microbial biomass, this fact showing a reactivation of the soil microbial population, possibly due to the incorporation with these organic materials of exogenous microbiota.

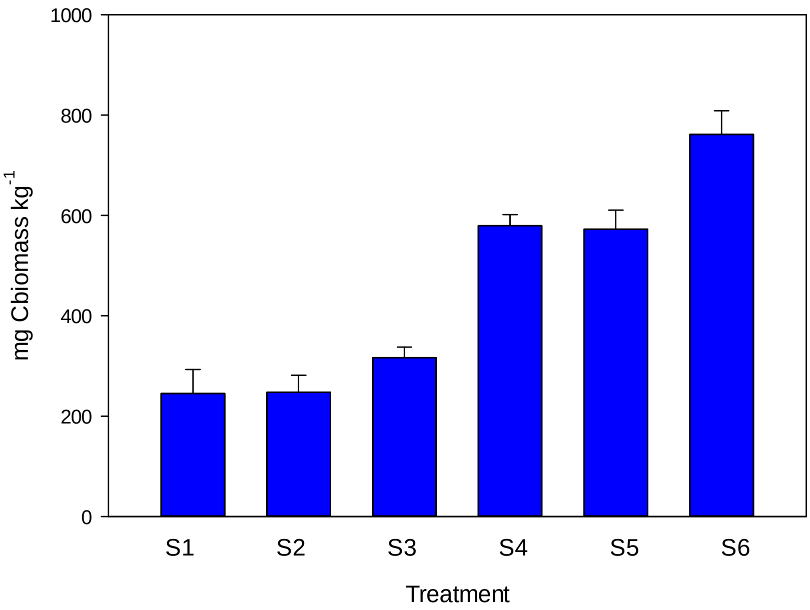

Figure 4. Microbial biomass C of the soils treated at the beginning of the experiment. S1 (control soil); S2 (soil + mineral fertilisation); S3 (soil + compost of cattle manure anaerobic digestate (dose 1:30 t /ha)); S4 (soil + compost of cattle manure anaerobic digestate (dose 2: 60 t/ha)); S5 (soil + compost of pig slurry anaerobic digestate (dose 1: 30 t/ha)); S6 (soil + compost of pig slurry anaerobic digestate (dose 2: 60 t/ha)).

Future collaborations and publications derived from this research stay

The research stay of Dr. Bustamante has supposed, not only the reinforcement of the scientific collaboration between the groups of Italy (IBAF-CNR) and Spain (CEBAS-CSIC), but also the incorporation into the project of an additional research group of Italy, belonging to the IRSA-CNR, with the researchers Dr. P. Grenni and Dr. A. Barra-Caracciolo, with the objective of increasing the knowledge about the effect of the organic amendments on the soil bacterial community activities, using additional analytical methods, such as the dehydrogenase activity and the bacterial viability. The first result of this collaboration has been the future participation in the 6th SETAC (Society of Environmental Toxicology and Chemistry) World Congress 2012 that will be held in Berlin on 20-24 May 2012, with the following communication based on this project:

"*Use of anaerobic digested-based composts as soil organic amendments: effect on the soil biological status*". Authors: Nogues I., Bustamante M.A., Loreto F., Moral R., Bernal M.P., Barra Caracciolo A., Grenni P.

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Stotzky, G., 1965. Microbial respiration. In: Blanck, C.A. (Ed.), Methods of Soil Analysis. American Society of Agronomy, Madison, pp. 1550–1570.

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Use of anaerobic digested-based composts as soil organic amendments: effect on the soil biological status.

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Climate changes together with organic matter and plant nutrient loss, low water infiltration and water holding capacity accelerate soil degradation. This is a serious problem for farmers and food suppliers and also for the reclamation of landscapes for nature conservation. Moreover, intensive livestock production has led to a generation of great amounts of animal manures and slurries that can constitute an environmental risk, if they are not managed properly. Consequently, there is a need for more environmentally sound methods for the treatment and utilisation of animal manure. Anaerobic digestion constitutes one of the main alternatives for managing it and is based on the anaerobic conversion of organic matter, obtaining biogas and a digested substrate called digestate. Although the latter presents a high fertilising value, this material shows some characteristics that make necessary to treat it prior to its direct soil application. One option is to separate the digestate into a liquid and a solid fraction, the latter can be composted to obtain valuable and marketable end-products, which can be used with agricultural purposes or for soil restoration. Within this context, different studies have shown that compost application increases soil organic matter content, improving physical, chemical and biological soil properties and thus, preventing soil erosion. The general aim of this work was to evaluate if the addition of two anaerobic digestate-based composts to a soil with a low C content could improve the overall microbiological activity and the C pool conservation. For this purpose, two composts (C1, mainly composed by cattle manure anaerobic digestate and C2, mainly composed by pig slurry anaerobic digestate), at two different rates (30 t/ha and 60 t/ha respectively) were incorporated into a semiarid soil from central Italy. Two other additionally treatments were also considered: the unamended soil (control) and a mineral fertilised soil. Subsequently, several plants of rosemary (*Rosmarinus officinalis*) were planted on these soils. The efficiency of the treatments was evaluated by analyzing soil physico-chemical and microbiological properties, such as soil respiration, microbial biomass and soil bacterial community activities, such as dehydrogenase and bacterial viability.

Keywords: composting; anaerobic digestate; semi-arid soil; microbiological indicators