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DYNAMICS OF SOIL MICROBIAL BIOMASS AND ORGANIC MATTER QUALITY FOLLOWING ADDITION OF PIG SLURRIES

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SUMMARY

The quality of organic matrices applied to soil, together with the dynamics of biotic components, are of great agronomical importance. The aim of this work was to investigate the behaviour of microbial biomass C in a subacidic and in a subalkaline soil amended with pig slurries and incubated at different temperatures.
A sub-acidic (pH 6.3) and a sub-alkaline soils (pH 7.8) were amended with two types of pig slurries (UPS, untreated pig slurry; SS, separated solids) at a rate of 2.2 g of organic matter kg^{-1} soil and incubated at 5, 20, 28 °C. Microbial biomass C (C_{mic}) was determined after 10, 120 and 300 days. Possible variations of soil organic matter quality were monitored by humification degree index after 120 and 300 days.
Slurry amendment roughly doubled C_{mic} in all treatments by day 10; the increase was more evident in the sub-acidic soil. Afterwards the dynamics of C_{mic} differentiated in relation to the type of amendment and incubation's conditions. At 5°C in both UPS-treated soils C_{mic} was greater than in SS-treated soil; the latter showed a significant decline from 120 days onward. At all, microbial biomass displayed a decreasing trend in both UPS and SS-treated soils, which was more evident in samples incubated at 28°C. Moreover, results showed that the addition of both types of pig slurry was able to sustain original amount of C_{mic}, while unamended soil was not.
Humification degree was influenced significantly only in sub-alkaline soil at 5°C, indicating a slower evolutive process of soil organic matter .
Results underline the beneficial effect of pig slurries amendment on soil microbial biomass and put in evidence the importance of temperature on the evolution of the organic matter.

Key words: Pig slurry, soil fertility, soil microbial biomass, heavy metals.

INTRODUCTION

Soil fertility is strongly affected by microbial biomass, a small fraction of the soil's total organic matter content, which is both a source and sink of nutrients and controls soil organic matter mineralization. The dynamics of biotic components, which are affected by environmental factors such as the characteristics of soil and temperature, together with the quality of organic matrices applied to soil, are of great agronomical importance. In fact, disturbing the biological equilibria by addition of unsuitable soil amendments causes changes in the composition and activity of soil biomass and can damage soil fertility both in short and long-term (Brookes, 1995; Leita et al., 1995; Leita et al., 1999). Addition of

organic wastes to soil is of benefit for maintaining soil fertility, but even the application of organic matrices could be penalised by the high content of undesired elements and/or organics. Increasing regulations and limitations concerning the application of organic wastes to soil are devoted to protect soil in the long term. This requires a detailed knowledge about fate of undesired substances in specific situations. It is well-known that pig slurries usually contain a significant amount of Cu and Zn, two potentially harmful metals for soil biota.
The aim of this work was to investigate the behaviour of soil microbial biomass and soil organic matter quality after addition of pig slurries in two different soils incubated at 5, 20 and 28 °C.

MATERIALS AND METHODS

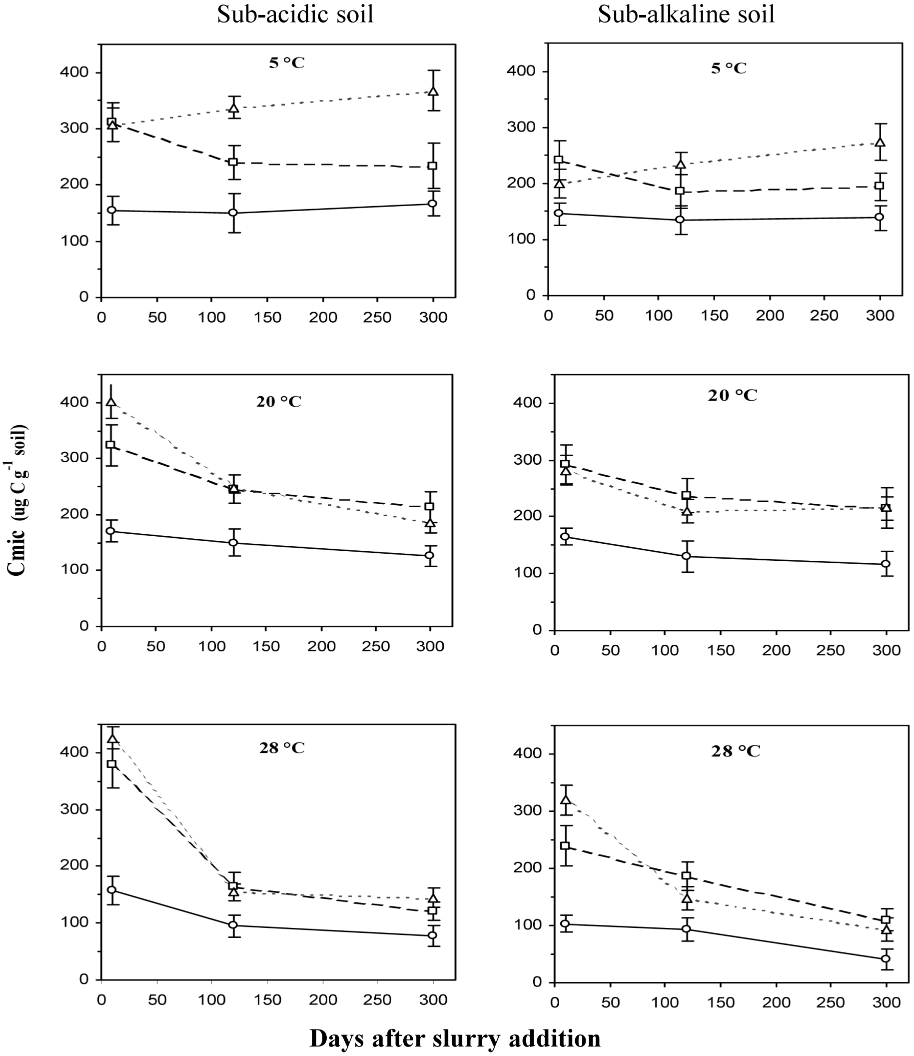
Two sandy loam soils with about the same amount of microbial biomass C (160 µg C g^{-1} soil) were used. Reana soil had a pH = 6.3, organic C and N content of 21 and 1.2 g kg^{-1} respectively; Rizzi soil had a pH of 7.8, organic C and total N of 11 and 1.2. g kg^{-1} respectively.
Samples (5 kg-oven dry basis) of both soils were amended with two types of pig slurries: UPS (untreated pig slurry) and SS (separated solids). UPS was taken from the tank placed under the grilled floor of a pig-staj. The tank is emptied every month and the slurry is treated aerobically for 1 day. After this treatment most of the solids are separated and constitute SS slurry. Slurry addition was performed at a rate of 2.2 g of organic matter kg^{-1} soil, corresponding to 450 m^3 ha^{-1} for a 2% organic matter content slurry. Content of copper and zinc in slurries was determined by microwave digestion with HNO_3 and atomic absorption spectrometry. UPS and SS contained 10.4 and 25.5 µg g^{-1} of Cu, 61.5 and 110.9 µg g^{-1} of Zn respectively. Soils were incubated at 5, 20, 28 °C for 300 days in the dark at 50% of their water-holding capacity.
Microbial biomass C (C_{mic}) was determined by fumigation-incubation method (Vance et al., 1987) after 10, 120 and 300 days. Humification degree (HD) (Ciavatta et al., 1991) was used as an index of soil organic matter quality. This procedure separates the humified from the non-humified fraction of alkaline (sodium pirophosphate 0.1 M plus NaOH 0.1 M) soil extracts by adsorption chromatography on polyvinylpirrolidone. The index expresses the percentage of extracted humified C over total extrated organic C.

RESULTS AND DISCUSSION

Microbial biomass. Ten days after of pig slurries addition, C_{mic} roughly doubled in both soils.
After that time, response of microbial biomass was different, depending on incubation temperature and type of slurry (figure 1).
At 5°C the addition of UPS to sub-acidic soil maintained high C_{mic} throughout the incubation time and even increased slightly, indicating that at this temperature the slurry was able to sustain the energy requirements of soil microbial biomass. On the contrary C_{mic} decreased by about 40% after 120 days in the SS treatment; this material contained a much lower amount of easily degradable organic C because it consisted for the most part of barley glumes. The same trend for C_{mic} was observed in the sub-alkaline soil, even though to a lower magnitude.
At 20°C, the addition of UPS caused, in the subacidic soil, a further increase of about 30%

of biomass C with respect to the 5°C incubation. The easily degradable part of the UPS was however rapidly consumed at 20°C and microbial biomass C decreased steadily throughout the experiment. After 300 days the microbial biomass C content of the UPS treated soil was very similar to that of the SS treated soil, but still significantly higher than the control.
At 28°C, the microbial biomass C in the UPS treated soil was more than twice the control 10 days after the addition of the slurry, but it rapidly decreased and after 3 months its amount did not differ significantly from that of the control at the beginning of the experiment. Microbial biomass C of controls decreased during incubation at 28°C due to the intensity of mineralization processes at this temperature.

Figure 1. Soil microbial biomass dynamics at different temperaures in sub-acidic soil (left) and sub-alkaline soil (right) after pig slurry addition (circles: unamended soil; triangles, untreated pig slurry (UPS); squares, separated solids (SS). Bars indicate standard deviation.



The effect was more pronounced in the calcareous Rizzi soil where at the end of the experiment the microbial biomass C was about half the original content.

Humification degree. Both slurry amendments did not influence significantly the humification degree of Reana soil, which remained constant around 66% value at any temperature.

In Rizzi soil a significant change occurred only at 5°C: the starting HD value (65 %) decreased slightly to 60 and 58% ($p<0.05$) respectively for SS and UPS treatment. No significant differences occurred at 20 and 28°C. This can be explained by the different velocity of slurry mineralization at different temperatures, as suggested by C_{mic} dynamics. In the Reana soil no variations of HD were detected, probably because this soil has a higher total C content, so the amount of slurry added was not sufficient to cause a significant change of soil organic matter quality.

CONCLUSIONS

Addition of pig slurries caused, on a short term, increases in the amount of soil microbial biomass, but the duration greatly decreased at higher temperatures. The effect of the application of pig slurries was over in about 3 months so that in a warm climate no residual effect of spring applications on soil biomass C level is likely to be detected at the beginning of autumn. The amount of easily degradable organic matter seems to be an important factor for long term microbial survival at low temperatures.

Slurry addition altered the HD only in the alkaline soil at 5°C.

In conclusion, quantitative response to pig slurry additions depended on the types of soil as well as on incubation temperature. However, a beneficial effect on C_{mic} was always observed without causing significant effects on soil organic matter quality at all.

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