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Anaerobic digestate from biogas production as a resource for improving soil fertility: effects on crop yield and soil properties

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Soil fertility is fundamental in determining crops productivity in all farming systems. Production of biogas through anaerobic digestion of energy crops generates residues that can represent a valuable resource to sustain and improve soil fertility and to increase soil organic matter content. Residues from anaerobic digestion contain organic fractions and available nutrients, that can thus be returned to the cultivation soil as fertilizer and soil conditioner.
However, some unknown aspects of digested residues utilization remain to explore: i) the nutrient supply and the real potential for mineral fertilization substitution, ii) the impact on the structure and functioning of soil microbial communities, iii) the direct and indirect effects on soil structure, organic matter and C mineralization.
The aim of the present research was to gain a better understanding of these aspects, evaluating the effects of anaerobic digestate application on soil properties and maize yield.
With the main focus of comparing mineral fertilization (250 Kg N ha-1) with digested residues addition (at the dose of 25 % and 50 % of mineral fertilizer), a triplicate sets of plots were designed in a field experiment on a silty-clay loam soil in the southern Po Valley (Italy). The amount of applied residues was calculated according to its N content in order to fertilizer each plots with the same amount of total nitrogen. Residues from digestion showed a N content of 0.4 % (60 % as N-NH4) and a C/N ratio of 3.
Changes in soil quality after residues application were studied with a holistic approach, involving microbiological, physical and chemical aspects of soil fertility. In particular, we determined: the abundance and diversity of bacterial and fungal soil communities; the soil organic matter content, its distribution within soil aggregates and the C mineralization potential; cation exchange capacity; the main macro and micro nutrients; bulk density; aggregate stability.
No significant differences among treatments were registered in the above ground maize biomass.
Molecular analysis conducted on microbial soil communities suggested that the application of digested residues to soil contributes to substantial modifications of both bacterial and fungal community structure. Soil organic C and total N increased in soils treated with digested residues addition, with no significant differences between the two doses of digestate. Cation exchange capacity did not show significant differences among treatments, remaining stable during the maize vegetative cycle. Differently, some variations occurred in the exchangeable cation pool. In particular, K content increased under digestate treatments, while Na and Mg contents increased with time irrespective of the fertilization treatment. No significant variations were observed in soil microelement levels, except for an increase in Zn content at the highest digestate dose. Moreover, digested residue addition had a positive impact on aggregates stability.
From the first results, the absence of negative effects in plant productivity and soil fertility after residues application, at both doses, is a promising indication for the potential use of anaerobic digestate as substitute of mineral fertilizers.