Pyrolytical Appraisal of Structural Changes in Soil Organic Matter Resulting from Long-Term Sustainable Practices in a Dryland Farming System

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Several changes in the chemical composition of the humic acids from semiarid experimental farm in Central Spain were found by analytical pyrolysis after 16 years of periodic inputs of farmyard manure (300 t ha⁻¹ every three years), or crop wastes (30 t ha⁻¹ barley straw every year plus 25 t ha⁻¹ of rape crop every three years). Half the experimental plots studied were treated with additional mineral N fertilization (100 kg ha⁻¹ of 33.5% NH₄NO₃).

The analytical pyrolysis suggested substantial changes in the biogeochemical mechanisms of accumulation of stabilized organic matter in soil. In fact, when compared with the control plots, the assemblage of pyrolysis compounds from the humic acids in the plots amended with lignocellulosic wastes displayed a well-defined lignin signature pointing to organic matter accumulation patterns based on diagenetic transformation of the most recalcitrant plant biomacromolecules. In particular, the highest yield of methoxyphenols was systematically observed in humic acids from the plots amended with mineral N-inputs. This fact could be due to the increased performance of the lignin biodegradation mechanisms in N-limited media, typically described in laboratory experiments. As in the case of lignocellulosic inputs (barley straw and rape crop), increased yields of lignin-derived methoxyphenol compounds were also observed in the plots treated with old manure, but the occurrence in the latter case of a diagnostic pattern of alkyl molecules suggested an incorporation of recalcitrant wax-derived lipids in the humic fractions. It is to indicate that the increased yields of alkanes and fatty acids in the humic acids extracted from the manure-amended plots were less significant in the subplots receiving N fertilization, what could be interpreted as the expected enhancement of microbial degradation of plant-inherited paraffinic molecules.

The relative abundance of typical pyrolysis products from humic acids, such as alkylbenzenes, was the most responsive parameter to the applications of external inputs of N, systematically showing increased values in plots receiving mineral N fertilization, in control plots or in plots receiving the different organic inputs.

In general, not only the yields of phenols but also those of aliphatic products in the humic acids extracted from plots receiving organic inputs were comparatively higher than those from the untreated plots. These changes do not coincide with those traditionally attributed to the formation of high-maturity humic acids after exhaustive depolymerization of plant-derived macromolecular material. The low-performance humification mechanism in the amended plots is interpreted as an effect of the biogeochemical constraints prevailing on semiarid conditions, where the maturation of the organic matter is limited to a short period with moisture and temperature suitable for the transformation of plant residues. In such a situation it seems that continuous inputs of plant wastes actually lead to increased levels of soil organic matter, but at the expense of the accumulation of raw humus made up of microbially reworked lignins.

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