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Short term impact of combining organic and mineral fertilization on soil quality of maize fields

Carla Ferreira, Adélcia Veiga, João Pato, Anne Karine, and António Ferreira
CERNAS, Coimbra Agrarian Technical School, Polytechnic Institute of Coimbra, Bencanta, Coimbra, Portugal

Maize represents one of the most important arable crops and one of the cereals with greatest expression worldwide. In 2016/17, global production attained 1,037.9 million tons, with USA and China being the largest producers (37.1% and 21.1%, respectively), whereas EU-27 produced 5.7% (USDA WASDE, 2017). Portugal provides 1.4% of EU maize (Eurostat, 2017), cultivated in 115.7 ha, representing 39% of all cereals area (Anpromis, 2017). High crop productivity is attained by intensive land management, involving, for example, several interventions with heavy machinery and high fertilization rates. These management practices lead to soil degradation and increasing use of inputs to maintain high crop productivity.
This study investigates the impact of combining organic fertilizers, specifically horse manure and sewage sludge from domestic wastewater treatment plants, with mineral fertilization on short term soil quality and maize production, in a conventional Portuguese arable farm. Three distinct fertilization practices were tested: (1) commercial mineral fertilizers (490 kg/ha); (2) composted sewage sludge (39.7 kg/ha); and horse manure from stables, with a high content of straw (38.6 kg/ha). Three plots of 6.8 m $\times$ 41 m were installed in each fertilized area. During sowing, additional mineral fertilization was similarly applied, together with seeds, in all the plots. Maize sowing was performed in May and harvesting in November 2017. Maize variety and plant density was the same in all the plots. In addition, management practices, including irrigation and pesticide application, was similar in all the plots over the crop season. Soil samples (0-15 cm and 15-30 cm) were collected immediately after sowing and before harvesting. Soil quality differences between fertilization types were assessed through (i) chemical properties, including pH, organic carbon, Kjeldhal nitrogen, plant available phosphorus and potassium, exchangeable cations (Ca, Mg, K, Na) and heavy metals (Cd, Cu, Zn, Cr, Ni and Pb); (ii) physical parameters, comprising bulk density, soil resistance and surface water infiltration; and (iii) biological indicators, consisting of decomposition and litter stabilisation rates, assessed over a 3-month period through the Tea Bag Index (Keuskamp et al., 2013), and the number of earthworms. Differences in crop yield were measured during harvesting.
The results of distinct fertilization practices did not show significant differences in chemical and physical soil parameters (except bulk density before sowing). The number of earthworms, however, was twice and three times higher in plots receiving sewage sludge and horse manure, respectively, than mineral fertilizer. As regards to crop yields, plots with horse manure displayed slightly lower production (10.05 kg/ha) than conventional fertilization (10.85 kg/ha) and sewage sludge application (10.95 kg/ha).
Short term application of organic fertilizers has an immediate impact on soil biodiversity, with positive impacts on soil quality. Nevertheless, long term studies are required to assess potential positive impacts on soil physical and chemical properties. Organic fertilizers, when combined with mineral fertilization, may provide similar crop yields while improving the soil quality, required to mitigate land degradation and improve agriculture sustainability.