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Direct and residual effects of manure on soil chemical properties

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The beneficial effects of manure recycling in cropland on soil fertility are well documented. Nowadays it can help sequestrate C in the soil organic matter, advocated to mitigate the atmospheric CO_2 increase. Because of the gradual disappearance of conventional livestock farming in Western Europe, the study of the persistence of the positive effects of manuring after its interruption can be interesting. Any research on soil fertility dynamic, however, requires long-term experiments because it is quite slow and greatly influenced by weather. A field trial, started in 1966 and still in progress in the Experimental Farm of Bologna University, compares 5 crop rotations (a 9-year course: corn-wheat-corn-wheat-corn-wheat-alfalfa-alfalfa-alfalfa, corn-wheat and sugarbeet-wheat, continuous corn and continuous wheat), at 3 levels of cattle manure supply combined with 3 inorganic NP fertilizers rates in a split-split plot replicated twice. The soil is an alluvial silty loam, fertile but low in organic matter (13.3 g kg^{-1}). Manure is spread before corn, sugarbeet and alfalfa, at a mean yearly rate of 0 (M0), 20 (M1) and 40 (M2) t ha^{-1} of fresh material. Since 1984 M2 has been interrupted to evaluate residual effects. Regarding mineral fertilizer rates, for this study we considered only the unfertilized control (N0P0) and N1P1 level, corresponding to a mean yearly application of 220 kg N ha^{-1} and 75 kg P_2O_5 ha^{-1}. Each year, since 1972 till now, we have sampled soil in the ploughed layer (0-0.4 m) to assess its pH (in water) and its content of organic carbon (SOC, Lotti method), total nitrogen (TN, Kjeldahl) and available phosphorus (P_2O_5, Olsen). To reduce the influence of crops and weather, statistical analyses were conducted on the averages of data obtained in the 4-year periods at the end of four 9-year cycles (1972-75, 81-84, 90-93 and 99-02).

In 30 years, the continuous M1 supply without any inorganic integration increased SOC, TN and P_2O_5 by +3.6 t ha^{-1} (+11%), +1.09 t ha^{-1} (+ 29%) and + 166 kg ha-1 (+107%), respectively, compared to the control. These significant increments were obtained linearly, at mean annual rates of: 0.15 t ha^{-1} $year^{-1}$ for SOC, 20 kg ha^{-1} for TN and 4.18 kg ha^{-1} for P_2O_5. During the first 18 years, doubling the manure supply (M2) caused further increments (72%, 76% and 112% increases for SOC, TN and P_2O_5, respectively, compared to M1).

The complete interruption of M2 application, from 1984 onward, gradually decreased the positive effects. In the 1990-93 period, no differences between M1 and M2 were detected. After 18 years all the amounts were lower in M2 than in M1. However, a residual effect of the double manuring was still evident: M2 plots had higher SOC, TN and P_2O_5, contents compared to the unfertilized control (+3.1 t ha^{-1}, +0.21 t ha^{-1} and +88 kg ha^{-1}, respectively).

Inorganic fertilization, in the absence of manure, did not affect SOC dynamic, whereas it had significant cumulative effects on TN (+0.94 t ha^{-1} (+26%) increase in the '99-02 period compared to the initial contents) and P_2O_5, with 223 kg ha^{-1} (+160%) increment.

Treatments slightly influenced pH (6.43, on average): compared to the unfertilized control, manure increased it a little (+2.7%), while mineral fertilization had an opposite effect (-2.7%).

In conclusion, the direct influences of manure on main components of soil fertility appeared cumulative with time and proportional to the application rates, at least up to 40 t ha^{-1} $year^{-1}$ of fresh material. Residual effects gradually disappeared, but at low speed, thus their study requires really long experiments, lasting more than 20-years. Inorganic fertilization could increase nitrogen and, even more, available phosphorus content in the soil, but, in our research where crop residues are always removed, it had a null effect on SOC.