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Humus and energy balances and greenhouse gas emissions with compost fertilization in organic farming compared with mineral fertilization

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The positive effects of compost fertilization on soil humus with their associated benefits for soil quality are well-established. The aim of the present study was to assess the effect of compost fertilization on humus and energy balances and greenhouse gas emissions and to compare the results of the humus balances with the changes in soil organic carbon contents measured in the soil of the experimental field.

In order to assess the effects of compost use in organic farming as compared to conventional farming practice using mineral fertilizers, the field experiment with compost fertilization ‘STIKO’ was set up in 1992 near Vienna, Austria, on a Molli-gleyic Fluvisol. It included three treatments with compost fertilization (C1, C2 and C3 with 8, 14 and 20 t ha-1 y-1 f. m. on average of 14 years), three treatments with mineral nitrogen fertilization (N1, N2 and N3 with 29, 46 and 63 kg N ha-1 y 1 on average) and an unfertilized control (0) in six replications in a latin rectangle design. In the field trial, biowaste compost from the composting plant of the City of Vienna was used. Data from the field experiment (from 14 experimental years) were fed into the model software REPRO to calculate humus and energy balances and greenhouse gas emissions. The model software REPRO (REPROduction of soil fertility) couples the balancing of C, N and energy fluxes. For the determination of the net greenhouse effect, REPRO performs calculations of C sequestration in the soil, CO_2 emissions from the use of fossil energy and N2O emissions from the soil.

Humus balances showed that compost fertilization at a rate of 8 t ha-1 y-1 (C1) resulted in a positive humus balance of +115 kg C ha-1 y-1. With 14 and 20 t ha-1 y-1 compost (C2 and C3), respectively, humus accumulated at rates of 558 and 1021 kg C ha-1 y-1. With mineral fertilization at rates of 29 – 63 kg N ha-1 y-1 (N1 – N3), balances were moderately negative (169 to -227 kg C ha-1 y-1), while a clear humus deficit of 457 kg C ha-1 y-1 showed in the unfertilized control.
Compared with measured soil organic carbon data REPRO predicted soil organic carbon contents fairly well with the exception of the treatments with high compost rates. Here REPRO clearly overestimated soil organic carbon contents for this site.
Energy efficiency, as described by the output/input ratio, was highest in the control, followed by C1. Mineral fertilization treatment N3 was most energy intensive.
The greenhouse gas balance indicated net carbon sequestration already with medium compost rates (C2), and net carbon sequestration of 1700 kg CO_2-eq ha-1 y-1 in C3. Mineral fertilization yielded net greenhouse gas emissions of around 2000 kg CO_2-eq ha-1 y 1. The highest greenhouse gas emissions had the unfertilized control due to the degradation of soil organic matter and lowest organic matter input.

These findings underline that compost fertilization holds a high potential for carbon sequestration and for the reduction of greenhouse gas emissions.