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Is organic farming environmentally more friendly?

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Reviews and meta-analyses generally support the perception that organic farming systems are more environmentally friendly than conventional farming systems. Organic agriculture results in more soil organic matter and higher microbiological activity, thus, providing better water holding capabilities, decreased both runoff and concentration of nitrate in soil, leading to fewer risks of nitrate leaching loss from the soil to water bodies. However, environmental quality parameters can differ between organic plant and animal production farms, moreover, they can be higher calculated per unit product.

We used the ARMOSA process-based crop model (Valkama et al., 2020) to evaluate contribution of plant and animal organic farming to soil organic carbon (SOC) sequestration and N leaching loss reduction compare to conventional systems in South Savo (Finland). Since organic systems often produce about 30% less yields compared to conventional systems, we calculated SOC changes per total gross energy in harvested yields. For model inputs we used daily meteorological data, statistical annual crop yields, statistical data for sales of nitrogen fertilizers in the region during the last 20 years (1999-2018). Five-year crop rotations were simulated on loamy sand soil (C 3.5 %, C/N ratio 17, pH 6.2). On plant production farms, rotations consisted of cereals (with addition of pea in organic), oilseed rape and grass. Conventional crops were fertilized with mineral fertilizer, and residues were removed (PC-R) or retained (PC+R). Organic crops were fertilized with green manure only (PO_g+R) or also with commercial organic fertilizer (PO_f+R). On animal production farms, conventional (AC-R) and organic (AO-R) rotations consisted of 2 years of cereals and 3 years of grass, sown with clover in organic system. Conventional animal system was fertilized with mineral fertilizer and slurry, while organic system with slurry only, and residues were removed in both systems.

Simulations showed that both conventional plant production systems (PC-R and PC+R) led to SOC decline of 650 kg $ha^{-1}yr^{-1}$ at 0-30 cm soil depth. Organic systems showed either less SOC decline (120 kg $ha^{-1}yr^{-1}$) as in PO_g+R, or slight SOC increase (55 kg $ha^{-1}yr^{-1}$) as in PO_f+R. In contrast, organic animal production system did not differ from conventional system in terms of SOC change, showing a slight decreasing trend of about 150 kg $ha^{-1}yr^{-1}$. Estimates of SOC per gross energy in harvested yields showed the highest value (1.3 kg GJ^{-1}) for organic plant production fertilized with commercial organic fertilizer (PO_f+R), while the lowest value (-18 and -13 kg GJ^{-1}) for conventional

plant production systems (PC-R and PC+R, respectively). In contrast, the estimates did not differ much between organic (-2.2 kg GJ^{-1}) and conventional (-1.8 kg GJ^{-1}) animal production systems. Simulated N leaching loss varied between 6 and 9 kg ha^{-1} yr^{-1} for all systems, except for organic plant rotation with green manure (PO_g+R), which N leaching loss was only 3 kg ha^{-1} yr^{-1}.

The modelling results suggest that organic plant production farms can be more environmentally friendly per unit area as well as per unit product compared to conventional farms, while organic animal production farms seem to cause similar environmental impact as conventional farms.