The DOK long-term experiment – lessons learned from 40 years of interdisciplinary research

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The world's growing population calls for sustainable food production within the limits of planetary boundaries. With respect to nitrogen and phosphorus cycling, the loss of biodiversity, land use change and the emission of greenhouse gases, four of these boundaries have been crossed already. Although fragmented knowledge of effects of different cropping systems on these focal planetary boundaries exists, there is a lack of comprehensive data from comparative cropping system experiments over the long run. Four decades back, farmers and researchers co-designed a system comparison experiment, located in Therwil (Basel-Land) Switzerland, comprising a seven-year ley crop rotation. Two conventional (with and without manure), and two organic systems (biodynamic and bioorganic) are compared. This experiment has served as a platform for national and international interdisciplinary research teams in the field of agronomy, soil quality, biodiversity, plant nutrition, food quality, sustainability assessment and modelling. Results of the 40years old DOK experiment show that organic systems, receiving distinctly less external inputs (chemical N, P, K and pesticides), maintained a higher biodiversity and produced lower greenhouse gas emissions. Yield averages over 40 years were 20% lower in organic systems across all crops. A nitrogen balance, including biological nitrogen fixation and stock changes of soil nitrogen, revealed a surplus for all manured systems, whereas the conventional system with sole mineral fertiliser was well balanced. Soil nitrogen stocks only increased slightly in the biodynamic system receiving composted manure. The biodynamic soil showed also increased soil organic carbon stocks, while the conventional soil receiving only mineral fertilizer acted as source for atmospheric CO_2. A climate impact analyses encountering nitrous oxide, methane and soil organic matter changes resulted in lower CO_2eq emissions in organic compared to the conventional systems, both area and yield scaled. Biodiversity and especially biomass of invertebrate fauna and plant seeds was enhanced in the organically managed systems. Our results demonstrate that organic cropping systems can contribute to a more sustainable production with respect to key planetary boundaries. To further improve system performance, yield gaps between organic and conventional systems need to be reduced by adapted cultivars, more effective organic plant protection and by closing urban and rural nutrient cycles.