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Efect of organic barley-based crop rotations on soil nutrient balance in a semiarid environment for a 16-year experiment

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In natural ecosystems with no percolating moisture regime, the biogeochemical cycle can be considered a closed system because the nutrients extracted by the roots will be returned to the soil after a certain time. In organic farming, a cycle model as close as possible is taken as a guideline, but we have to consider that unlike natural ecosystems, where most of the nutrients remain in the cycle, the agrosystems are open cycles. To achieve a sustainable fertility of the soil, the soil nutrient levels, the extractions according to the expected crop yields and the export refunds in the form of crop residues, biological nitrogen fixation, green manure or compost will have to be determined. Nutrient balance should be closed with external inputs, always avoiding to be a source of negative impacts on the environment. In organic farming without exogenous inputs, the effect of the crop rotations is much more noticeable in the nutrient balance than in the conventional farming fields which every year receive inputs of nutrients (nitrogen, phosphorus and potassium) in the form of chemical fertilizers. The most extractive crop rotations are those that produce a greater decrease in soil reserves, and in these cases exogenous inputs to maintain sustainability should be considered; however, in less extractive crop rotations, extractions can be restored by the edaphogenesis processes.

In this work, soil organic matter, phosphorus and potassium balances were analyzed in different organic barley-based crop rotations (barley monoculture [b-b] and in rotation with vetch for hay production [B-Vh], vetch as green manure [B-Vm], sunflower [B-S], chickpea [B-C] and fallow [B-F]) in clay soils under a semiarid environment ("La Higueruela" Experimental Farm, Santa Olalla, Toledo, central Spain) over a 16 year period. Additionally, barley monoculture in conventional farming [B-B] was included. In the organic system, the fertilization involved the barley straw in all rotations, the sunflower straw in B-S, the symbiotic nitrogen from the vetch crops and the green manure in B-Vm. In the conventional system, fertilization consisted on barley straw and chemical fertilizers at a rate of 80-60-30 kg N-P-K ha-1. Before the organic management, the whole plot was subjected to conventional practices.

The highest total yields (and therefore the nutrients extractions) were obtained in B-Vh, followed in this order by B-B, B-S, B-F, B-Vm, B-C and b-b. The crop rotations with the highest yields favoured the microbial activity and the organic residues mineralization, although this caused, eventually, a small decrease in the soil organic matter content. Since the eighth year, this parameter remained more stable until the end of the study period. The highest decrease of soil organic matter took place in B-F and B-S, while the lowest ones happened in B-B, where the great amounts of barley straw incorporated into the soil compensated the organic matter losses.

The conversion from conventional to organic management with the incorporation of the straw to the soil implies a re-adaptation process with a decrease of the soil phosphorus level by the increasing soil microbial biomass. A decrease of phosphorus during the first six years of the experiment and a posterior recovery and stabilization of this ratio by the solubilisation of the fixed phosphorus was observed. B-F and B-S presented the lowest soluble phosphorus losses, while B-C the highest ones. In the same way, the potassium level decreased during the first eight years and after that remained constant. The highest decreases took place in the rotations with the biggest amounts of barley straw; this decrease could be explained by the nutrient immobilization caused by the microbial biomass.