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Energy balance in rainfed herbaceous crops in a semiarid environment for a 15-year experiment. 2. Impact of crop rotations.

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Energy balances in agriculture production have been widely studied since the 1970s. Researchers have performed detailed energy balances for different crops and farm management systems all over the world in attempts to assess the efficiency and environmental impact of production systems.

This work is part of a larger study assessing the effects of three farming systems (conventional, conservation with zero tillage, and organic) and four barley-based crop rotations (barley followed by fallow [B-F], barley in rotation with vetch for hay production [B-V] or sunflower [B-S], and barley monoculture [B-B]), on the energy balance of crop production under the semi-arid conditions over a 15 year period. However, the present work is focused on the crop rotation effect, so farming systems and years are averaged.

Experiments were conducted at “La Higueruela” Experimental Farm (4º26’ W, 40º04’ N, altitude 450 m) (Spanish National Research Council, Santa Olalla, Toledo, central Spain). The climate is semi-arid Mediterranean, with an average seasonal rainfall of 480 mm irregularly distributed. The rotations were simultaneously duplicated to have all phases of each rotation present every year. Results were expressed with respect to one hectare and year for a complete rotation. The energy balance method used required the identification and quantification of all the inputs and outputs implied, and the conversion to energy values by corresponding coefficients. The parameters considered were (i) energy inputs (EI) (diesel, machines, fertilizers, herbicides, seeds) (ii) energy outputs (EO) (energy in the harvested biomass), (iii) net energy produced (NE) (EI - EO), (iv) the energy output/input ratio (O/I), and (v) energy productivity (EP) (Crop yield/EI).

Total EI varied from 6.19 GJ ha-1 year-1 for B-F to 11.7 GJ ha-1 year-1 for B-B, that indicates that the energy requirements of barley monoculture (B-B) are almost double those when a fallow period is included in the rotation. Fertilizer was the main energy input, accounting from 52% in B-V to 62% in B-B. EO increased in the order B-B (19.1 GJ ha-1 year-1) [U+F0BB] B-F < B-S < B-V (29.3 GJ ha-1 year-1, 53% higher). With respect to individual crops, the highest EO was recorded for barley in all cases, followed by vetch and sunflower. B-V produced the highest net energy (21.0 GJ ha-1 year-1), while B-B was associated with the lowest (7.41 GJ ha-1 year-1, or 65% less). O/I rank order was B-V (4.23) > B-F > B-S > B-B (2.00), indicating the low energy use efficiency of barley monoculture. Vetch was the most energetically efficient crop (yield/input), a result of the low requirements for producing a unit of vetch hay. EP ranged from 360 kg GJ-1 for B-V to 137 kg GJ-1 for B-B.

As conclusions and in terms of energy efficiency, cereal monoculture, independent of the crop management system used, appeared to be an energetically unsustainable practice. However, crop rotations, especially those that include a leguminous crop, increase energy efficiency.