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Energy balance in rainfed herbaceous crops in a semiarid environment for a 15-year experiment. 1. Impact of farming systems

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During the last years, agricultural practices have led to increase yields by means of the massive consumption on non-renewable fossil energy. However, the viability of a production system does not depend solely on crop yield, but also on its efficiency in the use of available resources. 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 monoculture and in rotation with vetch, sunflower and fallow) 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 farming system effect, so crop rotations 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 and a 4-month summer drought period. Conventional farming included the use of moldboard plow for tillage, chemical fertilizers and herbicides. Conservation farming was developed with zero tillage, direct sowing and chemical fertilizers and herbicides. Organic farming included the use of cultivator and no chemical fertilizers or herbicides. 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).

EI was 3.0 and 3.5 times higher in conservation (10.4 GJ ha-1 year-1) and conventional (11.7 GJ ha-1 year-1) than in organic farming (3.41 GJ ha-1 year-1). The difference between conservation and conventional systems was as result of the greater use of machinery and, consequently, of fuel in conventional, though the use of herbicides was slightly lower. In both systems, fertilizer was the most important energy input. EO was lower for organic (17.9 GJ ha-1 year-1) than for either conventional or conservation systems (25.7 and 23.4 GJ ha-1 year-1, respectively), a result of the lower barley grain and vetch hay yields. The highest NE was obtained in organic (14.5 GJ ha-1 year-1), and the lowest in conservation (13.0 GJ ha-1 year-1). In relation to O/I, organic farming were about 2.3 times more energetically efficient (5.36) than either the conventional or conservation systems (about 2.35). EP ranged from 400 kg GJ-1 in organic to 177 kg GJ-1 in conventional. No differences in all the energy variables considered were recorded between the conventional and conservation managements.

As conclusions and in terms of energy efficiency, farming systems requiring agrochemicals in semi-arid Mediterranean conditions, whether conventional or conservation, appeared to be little efficient. Chemical fertilizer was the most important energy input in these two systems, but their use did not lead to an equivalent increase in yield because of the irregular distribution in many years. Organic farming would improve the energy efficiency in these environmental conditions, offering a sustainable production with minimal inputs.