Energy use in organic farming

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Key words: energy, organic, biodynamic, fossil-fuel

Abstract

Within this review, the extent to which organic farming can offer a more energy efficient mode of production was investigated through a comparison of 50 studies. The results illustrate that for nearly all crop and livestock types, organic systems use less fossil-fuel energy on a unit of land area basis, although results are more variable per unit of product. In many cases the difference can be attributed to the high energy requirements for the manufacture of nitrogen fertiliser used in conventional systems. Lower yields and higher energy requirements for weed control can make some organic cropping systems perform worse. Higher feed conversion ratios and mortality rates also make some organic livestock systems less efficient per kilogram of meat produced. Overall the review has found that organic farming systems have the potential to contribute towards a more energy efficient agriculture, although this will be at the expense of a lower yield.

Introduction

Limited fossil fuel reserves, growing populations and rising input prices highlight the importance of increasing the efficiency of food production systems and reducing greenhouse gas emissions. The organic sector places an emphasis on reducing inputs to the farm and recent reviews have found that organic farms use less fossil energy use and emit less greenhouse gases when results are expressed per hectare (Lynch et al. (2011), Gomiero (2008) and Lampkin (2007). When comparisons are made per unit of product, results are less consistent, with some organic production systems requiring more energy, due to a lower yield. The above reviews also found that the variety in energy assessment methods makes comparisons between studies difficult and that results varied greatly depending on whether the conventional systems used intensive or extensive production methods. The aim of this review was to build on previous work, providing a more complete and up-to-date assessment of the comparative energy efficiency of a range of organic systems.

Material and methods

A literature review of organic/conventional energy use studies was carried out in 2012 using web based search engines. The following or similar search terms were used:

- energy, emergy, fossil fuel
- organic, biodynamic, agro-ecological
- life cycle assessment, LCA, emergy, thermodynamic
- comparison, compare

The review only included studies based on pairwise comparisons and publications had to contain energy use data on both organic and conventional agriculture. Comparisons were made for each product group in relation to the amount of energy required per unit of product (e.g. kilograms or litres) in addition to the amount used per unit of land.

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Results

Organic systems consistently use less fossil-fuel energy on a unit of land area basis for nearly all crop and livestock types, as shown in Figure 1.

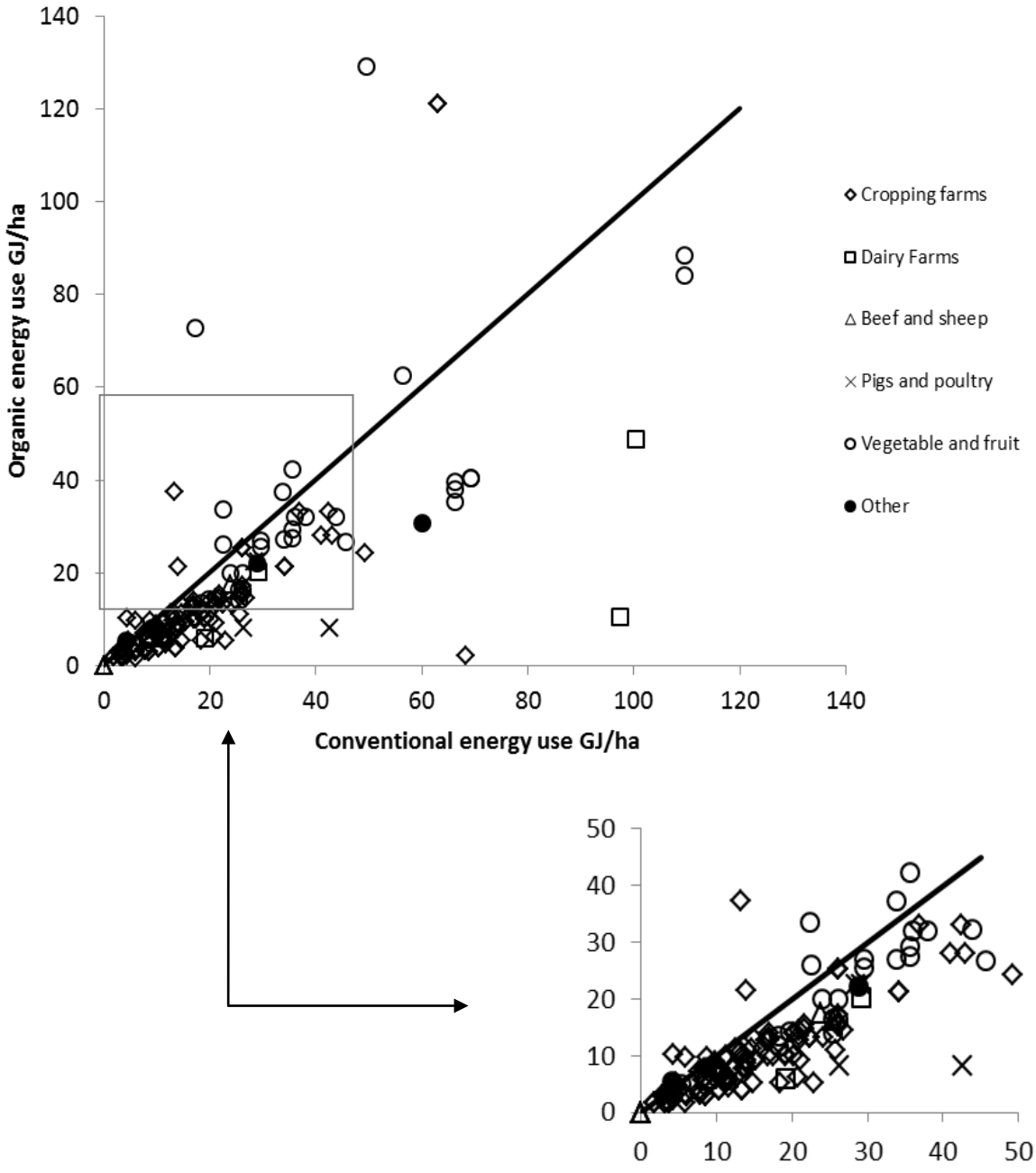

Figure 1: Organic vs conventional energy use per hectare with expanded selection. Organic performs better below the line, worse above the line. Please note the 'trend-line' is x=y for the purposes of illustrating the relative performance for each product type and is *not* a line of best fit.

In many cases the difference can be attributed to the high energy requirements for the manufacture of nitrogen fertiliser. Results are more variable per unit of product, where lower yields and higher energy requirements for weed control can make some organic cropping systems perform worse (see Figure 2). For example, for organically produced potatoes, energy use tends to be greater due to yield losses from pests and disease, causing lower yields overall (Williams et al., 2006). Higher feed conversion ratios and mortality rates also make some organic poultry systems less efficient per unit output (Leinonen et al., 2012).

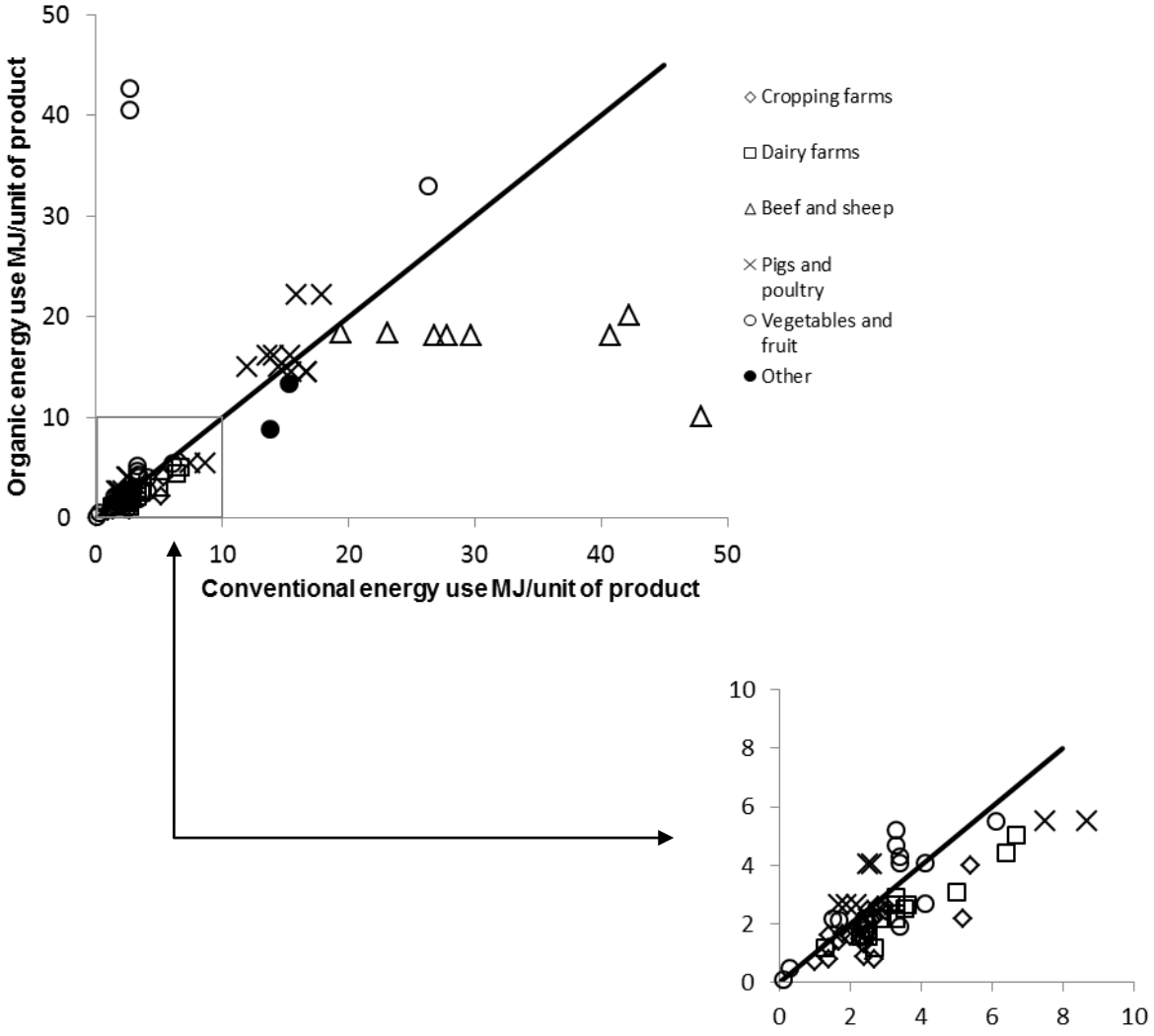

Figure 2: Organic vs conventional energy use per unit of product with expanded selection. Organic performs better below the line, worse above the line. Please note the 'trend-line' is x=y for the purposes of illustrating the relative performance for each product type and is not a line of best fit. Units of production were not consistent across the studies compared.

For most grazing systems, organic farming will result in a lower energy use, on a unit area or weight of product basis. This is a direct result of the use of clover and other forage legumes within leys, which results in more efficient forage production compared to the conventional practice (e.g. Küstermann et al., 2008). Similarly, for dairy systems, organic production tends to result in lower energy use per litre of milk produced, due to greater energy efficiency in the production of forage and reduced reliance on imported concentrates (Cederberg and Mattsson, 2000; Haas et al., 2001; Thomassen et al., 2008). With regard to on farm energy use, in common with Lynch et al. (2011) this review has found that in many cases organic farmers' diesel

requirements are comparable to conventional; although for some crops this energy source may be greater through increased reliance on mechanical tillage, e.g. for broccoli (Venkat, 2012), wheat and potatoes (Williams et al., 2006). Higher human energy (labour) requirements were also found on organic farms because of increased mechanical weeding and greater diversity (Nguyen and Haynes, 1995).

Discussion

Overall, the review found that organic farming systems have potential to contribute towards more efficient agriculture, but with lower yields. The review also highlighted that organic systems do not offer a radical alternative, as they are still reliant on fossil fuel sources and the differences in energy use per unit of product were often marginal. Organic methods could still be applied to increase the efficiency of the agriculture sector as a whole, although energy use is only one aspect of sustainability.

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References

Cederberg C & Mattsson B (2000): Life cycle assessment of milk production — a comparison of conventional and organic farming. Journal of Cleaner Production 8, 49-60.

Gomiero T, Paoletti MG & Pimentel, D (2008): Energy and Environmental Issues in Organic and Conventional Agriculture. Critical Reviews in Plant Sciences 27, 239-254.

Haas G, Wetterich F & Köpke U (2001): Comparing intensive, extensified and organic grassland farming in southern Germany by process life cycle assessment. Agriculture, Ecosystems & Environment 83, 43-53.

Küstermann B, Kainz M & Hülsbergen KJ (2008): Modeling carbon cycles and estimation of greenhouse gas emissions from organic and conventional farming systems. Renewable Agriculture and Food Systems 23(01), 38–52.

Lampkin N (2007): Organic Farming's Contribution to Climate Change and Agricultural Sustainability. Welsh Producer Conference, Builth Wells.

Leinonen I, Williams AG, Wiseman J, Guy J & Kyriazakis I (2012): Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment: Broiler production systems. Poultry Science 91, 8-25.

Lynch D, MacRae R & Martin R (2011). The Carbon and Global Warming Potential Impacts of Organic Farming: Does It Have a Significant Role in an Energy Constrained World? Sustainability 40.

Nguyen ML & Haynes RJ (1995): Energy and labor efficiency for 3 pairs of conventional and alternative mixed cropping (pasture arable) farms in Canterbury, New-Zealand. Agriculture Ecosystems & Environment 52, 163-172.

Thomassen MA, van Calker KJ, Smits MCJ, Iepema GL & de Boer IJM (2008): Life cycle assessment of conventional and organic milk production in the Netherlands. Agricultural Systems 96(1–3), 95–107.

Venkat K (2012): Comparison of Twelve Organic and Conventional Farming Systems: A Life Cycle Greenhouse Gas Emissions Perspective. Journal of Sustainable Agriculture 36, 29.

Williams AG, Audsley E & Sandars DL (2006): Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Main Report. Defra Research Project IS0205.