Is Agroecology the most sustainable approach for all organic farming systems?

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Implications

Analysis of very diverse Italian organic production systems through dedicated research projects revealed that all of them have ample margins of improvement in sustainability. The 'multifunctional organic system' (small-scale farms, produce sold on local or regional markets, agroecologically-based management) must seek optimisation of production, cost reduction, and a better access/distribution of labour in peak times. The 'specialised organic system' (medium-large farms, produce sold on supermarkets or abroad, input substitution-based management) should seek viable, more ecologically-based alternatives to input substitution to mitigate its high environmental impact. Literature suggests that this divergence between organic production systems is occurring in many countries. National and international organic standards should not only be more aligned towards their claimed sustainability objectives but also clearly distinguish from future integrated production standards. Incorporation of more agroecologically-based management options (e.g. functional biodiversity) should help keep organic farming duly identifiable by people, but practical solutions would need to be tailored to the specific production system.

Background and objectives

Agroecology can be considered a scientific discipline, a series of cultural practices and/or a social movement aiming at developing cropping and farming systems based on the best use and conservation of natural resources and the minimum use of external inputs (Wezel et al 2009). IFOAM and TP Organics Europe have defined a series of agroecological principles that are highly recommended for planning organic farming systems. These include: the optimisation of soil nutrient cycling, the increase in soil organic matter and fertility, the reduction of dependency on external inputs, and aspects related to socio-economic equity and sustainability (http://agro-ecoinnovation.eu).

Raising external and internal pressures demand an answer to the question: 'Is organic farming really sustainable?' More specifically, are the three pillars of sustainability (environmental, economic and social) equally important in all organic farming systems? It is obvious that 'organic farming' is not a monolithic category and that huge differences exist among different organic production systems, although this is rarely communicated to the larger public. In many countries there is a continuum of organic production systems ranging between multifunctional small-scale farms producing a plethora of produce for local or regional markets with agroecologically-based methods ('multifunctional organic systems') and specialised medium-large farms producing for supermarkets and the export with input substitution-based methods ('specialised organic systems') (Bàrberi 2010). In Italy, this divergence is particularly evident given the fact that in conventional agriculture mixed crop-livestock systems are uncommon, a structural problem which is difficult to overcome with conversion to organic farming.

The general objective of this paper is to evaluate the overall sustainability level of very diverse organic production systems (multifunctional *vs* specialised) typical of the Italian situation, through the results of four dedicated national or regional research projects (FERTORTOMEDBIO, SIMBIOVEG, ARIA and SATREGAS). The specific objective is to highlight the weak elements of sustainability for both organic production typologies and suggest possible solutions.

Key results and discussion

FERTORTOMEDBIO project. The SMS showed a lower total weed biomass at spinach harvest than PWC and PWC+LM thanks to the presence of the plastic mulch, but values were overall low (from 0.2 to 2.4 g m^{-2}). The biomass returned to the soil by PWC+LM was nearly double that in PWC, including 20 kg ha^{-1} of N provided by the subterranean clover living mulch. There was a significant negative association (r^2 = 0.44*) between living mulch biomass and weed biomass. Spinach yield and biomass $plant^{-1}$ were on average 31% and 33% higher in PWC and PWC+LM than in SMS. Total production costs were nearly threefold in SMS than in the innovative systems due to huge labour costs for manual transplanting (calculated based on standard salaries for non specialised agricultural workers in the region). Actually, labour costs were not borne by the farmer because he employed disabled people thanks to a social agriculture project he was involved in. This was the only reason that made his production economically sustainable, otherwise he would have suffered a gross margin loss of >4000 € ha^{-1}. Despite the availability of low-cost labour, the farmer was unable to manage his summer crops (e.g. tomato) satisfactorily due to lack of management skills and labour mismanagement at peak times.

SIMBIOVEG project. Compared to optimum values, the 12 organic vegetable farms showed better values for indicators like average soil cover during the whole year (89.4%) and the most critical season (78.3%), genetic agrobiodiversity (45 cultivars, including an average of 3.68 traditional varieties $farm^{-1}$), species agrobiodiversity (crop rotation), and habitat agrobiodiversity (high richness and diversity of ecological infrastructures). However, critical values were shown for other indicators like soil NPK concentration [e.g. 408 kg NO_3^- vs an optimum value of <70 kg, too large, long and adjacent fields, and insufficient share of woodland (<4% of the total farm area)]. The most striking negative indicator was the energy balance (output-input), on average -4704 kg. It was clear that these farms were not fully environmentally sustainable, mainly due to excess reliance on external inputs, although they fully complied with the provisions of the EU Regulation on organic farming.

ARIA and SATREGAS projects. LCA analysis based on actual farm, processing and retail data showed a huge variation in the estimated CO_2 release from the different processing tomato production and retail systems. The lowest emissions (58.0 kg CO_2 kg $produce^{-1}$) were found for the organic open field production sold via box scheme and the highest (291.7 kg CO_2 kg $produce^{-1}$, i.e. fivefold) for the organic cold greenhouse production sold packed in supermarket. In the latter case, 51% of total emissions were due to the processing, delivery and packaging phases *vs* 3% in the former case. Noticeably, the production site (open field *vs* greenhouse) and the retail system had a much higher effect on CO_2 emissions than the production method (organic *vs* integrated). These results indicate that, for the same produce, there can be tremendous differences in the environmental impact of different organic production and retail systems, which is systematically much higher in 'specialised organic systems' than in 'multifunctional organic systems'. This evidence may open roads to new voluntary certification schemes quantifying the contribution of a given typology of organic farming to the reduction of greenhouse gas emissions.

Results of these four projects show that both organic production systems should improve their sustainability. In the case of 'multifunctional organic systems', the main priority is to increase farmers technical skills, which are often poor, resulting in sub-optimum farm management and yields and consequently in too high prices, unjustified for produce that are sold directly on farm or through local retail systems with reduced food mileage. In the case of 'specialised organic systems', the main priority is to (re)introduce or optimise some agroecologically-based methods (e.g. agronomically-sound crop sequences, cover crops/living mulches, intercropping), which are often surprisingly considered a necessary evil. This would reduce dependence on external inputs, improve the environmental sustainability of these systems (a problem mainly in specialised organic vegetable production), and revert the trend towards 'conventionalisation' of organic farming, which is being considered as one of the major threats to the whole organic sector (Best 2008; Darnhofer et al. 2010).

How work was carried out?

FERTORTOMEDBIO (2005-09): this was a national project aimed to improve soil fertility management in organic vegetable systems. Our activities were carried out in a vegetable farm (ca. 4 ha) representative of the 'multifunctional organic system' typology. The standard farm management system (SMS), based on manual transplanting on plastic mulch, was compared with two innovative systems, one based on physical weed control (PWC), and one on its integration with a *Trifolium subterraneum* living mulch (PWC+LM). Data on total and weed biomass, spinach yield, production costs and gross margins are shown.

SIMBIOVEG (2005-09): this was a large national collaborative project aimed to develop innovative systems and methods for arable and vegetable organic crops and to test their effects on produce quality and environmental and economic sustainability. Here, data on several indicators of agri-environmental sustainability assessed in 12 vegetable farms, mainly representative of the 'specialised organic system' typology, are reported. These indicators were classified in three categories: (1) soil and water, (2) landscape and biodiversity, (3) agronomy and energy.

ARIA and SATREGAS (2009-12): these were two regional projects aimed to analyse the environmental sustainability of various integrated and organic production and retail systems and the way to communicate it to the larger public. Here, data on estimated unit emissions (kg CO_2 kg produce^{-1}), as based on Life Cycle Assessment (LCA) analysis, are shown for 20 processing tomato systems, given by the combination of 4 production systems (integrated *vs* organic in cold greenhouse *vs* open field) and 5 retail systems (packed produce of extraregional *vs* regional origin sold in supermarket, unpacked produce sold in supermarket, unpacked produce sold in specialised shop, unpacked produce sold via box scheme).

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