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The role of organic farming for food security: local nexus with a global view

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Abstract

A convergence of factors has made food security one of the most important global issues. It has been the core concept of the Milan Expo 2015, whose title, Feeding the Planet, Energy for Life, embodied the challenge to provide the world's growing population with a sustainable, secure supply of safe, nutritious, and affordable high-quality food using less land with lower inputs. Meeting the food security agenda using current agricultural production techniques cannot be achieved without serious degradation to the environment, including soil degradation, loss of biodiversity and climate change. Organic farming is seen as a solution to the challenge of sustainable food production, as it provides more nutritious food, with less or no pesticide residues and lower use of inputs. A limit of organic farming is its restricted capability of producing food compared to conventional agriculture, thus being an inefficient approach to food production and to food security. The authors maintain, on the basis of a scientific literature review, that organic soils tend to retain the physical, chemical and biological properties over the long term, while maintaining stable levels of productivity and thereby ensuring long-term food production and safety. Furthermore, the productivity gap of organic crops may be worked out by further investment in research and in particular into diversification techniques. Moreover, strong scientific evidence indicates that organic agricultural systems deliver greater ecosystem services and social benefits.

Introduction

In recent decades, sharp rises in food prices and the growing level of hungry and malnourished people on the planet (Dawea and Maltsogloub, 2014), as well as a series of multiple stresses, including climate change, soil, water and air pollution that are affecting crop productivity (FAO, 2015), have raised awareness among policy makers and the general public with respect to the fragility of the global food system.

The significance of the issue was highlighted by the 2015 edition of the Universal Exposition held in Milan. The core theme chosen for the EXPO Milano 2015 was Feeding the Planet, Energy for Life—with a principal focus on the right to food for all the world's inhabitants- demonstrates the urgency of the problem and invites politics, science and business to find solutions of how to sustainably feed the planet and reduce hunger. The theme of Expo Milano 2015 reflects the title of an outstanding FAO conference held in 2009, titled How to feed the world in 2050, where experts from all continents met to discuss

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and put forward solutions to ensure food security by 2050. By that date demographers consider that the world population will reach 9 billion people and the global demand for food may increase by 70% vis-a-vis to the current demand (Godfray et al., 2010).

Currently more food is produced than needed to feed the entire world population; despite this fact, food availability will not comply with the rising demand of the planet. It means that the foremost hunger problem today is one of food distribution rather than food shortages. Today we are faced with issues of over- and under-nutrition: more than a billion people today are chronically underfed simply because they are too poor to buy the food that abounds, while much of the developed world is at the same time facing a crisis of obesity and diet-related diseases, such as cardiovascular disease, hypertension, cancer, diabetes and non-alcoholic fatty-liver disease.

Thus, simply increasing global supplies will not solve the distribution problem. However, it is clear that world food demand will continue to grow and there will be a need to grow more food. This can be achieved by increasing productivity or by expanding the total cropped land area, the demand for land conversion. The projected need for additional cropland and grassland areas implies further risks of deforestation and other land-use changes, like for example the conversion of semi-natural grasslands. This will most likely affect biological integrity, which underpins the ecosystem services and well-being of local and global communities (Maes et al., 2012). The article How Much Land Can Ten Billion People Spare for Nature? by Paul Waggoner (1997) is an important contribution towards dealing with dilemma posed by demographic trends and increased global demand for food and the compatibility between the strategies for global food security and those for nature conservation, but also on greenhouse gas emissions, soil degradation, alteration of hydrological cycles and global nitrogen and phosphorus dynamics. Change in land use also impacts livelihoods and economic systems, migration patterns and social cohesion, and on cultural norms and preferences. Along with land use change, social and economic value systems can change; markets and trade opportunities can change and political, economic, cultural and social capitals can change.

Other elements of concern with respect to food security arise from endogenous (food or non-food products, such as biofuels and bioplastics) and exogenous (for water and land resources resulting from other productive sectors and the expansion of urban settlements and infrastructure) antagonisms within the agricultural system itself. These kinds of agricultural problems are connected with the concerns about the pressures arising from the intensification and expansion of modern agriculture, which is considered a major driver of climate change, land-use change, loss of biodiversity integrity and modification of nitrogen and phosphorus cycles (Hole et al., 2005; Rockström et al., 2009; Steffen et al., 2015)

To promote global food and ecosystem security, several innovative farming systems, alternative to conventional agriculture, have been identified. They include integrated, conservation agriculture, mixed crop/livestock, and perennial grains. Organic agriculture is the most popular alternative farming system, especially in Europe and North America. Some authors maintain that this approach is dangerous because organic agriculture should not be considered more sustainable because they may require more land for production. Further, organic farming does not necessarily lead to a better environment or better food products (Kirchmann and Thorvaldsson,2000) and it does not produce nutritious, affordable and accessible food in a socially and environmentally sustainable manner. Finally, broad-scale adoption of organic practices could result in decreased yields in organic system because of reduced nitrogen deposition from conventional farms.

Hence, the key issue of the debate has to do with the contribution that organic farming can make to the future of global agriculture. Will organic farming be able to produce enough food to feed an overpopulated world, ensuring food security,across the planet in next few decades, and at the same time preserving natural environment and providing short and long-term ecosystem services and benefits for society?

The choice of organic farming

Organic farming is an alternative to conventional agricultural systems for the aspects related to both

Figure 1: The EU logo (better known as Euro-leaf), made mandatory for all EU organic products and manufactured, according to the regulations of the Council EC / 834/2007 and EC / 889/2008. The Euro-leaf, which use is governed by EC Regulation 271/10, may be applied on a voluntary basis in the case of organic products not packaged or other organic food imported from third countries. For processed products, to classify them as "organic", at least 95% of ingredients must be organic.

the management of the farm and the production system. Organic farming or «bio», to use the name with which it is known in Italy, has as its main objective not the achievement of high levels of production but maintaining and increasing levels of organic matter in soils (hence the term organic farming used in England, where organic farming has taken the first steps). Thus organic farming reduces or eliminates the intake of synthetic fertilizers, herbicides, pesticides and pathogens. Only manual, mechanical and thermal practices are permitted for weed control. Wildlife species (insects, mites, snails, etc.), considered crop parasites, can be controlled through biotechnology measures or natural insecticides. This organic production method thus plays a dual function: the first responds to the demand from consumers for healthy and safe food; the second towards the public good, through a contribution to the protection of the environment, animal welfare and rural development.

In Europe, organic production and labelling is governed by a specific regulation, EC Regulation 834/2007 and the subsequent amending and correcting EC regulations 889/2008, 505/2012 and 354/2014. These contain a number of common provisions regarding production methods, product labelling, control system and financial measures to support organic farming. The regulations also integrate measures aimed at protecting the environment and biodiversity (Ciccarese and Silli, 2014). In particular, the EC Regulation 834/2007 provides for the mandatory use of the organic label, which is associated with a numerical code coupling with the proper logo, indicating the country, the type of production method, the operator code and the control code (Figure 1).

Organic farming in Italy and in the world

In 2013 the amount of land used for organic farming across the world reached 37 million hectares (Mha) (FIBL-IFOAM 2015). This figure is 3% higher than the previous year's figure. The largest area of land under organic cultivation is in Oceania, with about 12 Mha, or 40% of the world's total (Figure 2). In Europe organically cultivated land covers 11.5 million hectares. In the European Union (EU) 10.2 million hectares are organically farmed, representing 27% of the world's total. The EU countries with the largest organic areas are Spain (1.6 Mha), Italy (1.3 Mha) and France and Germany (1.1 Mha each). The share of organic agricultural land is more than 10% in eight European countries, with Liechtenstein (31%), Austria (19.5 %) and Sweden (16.3 %) having the highest organic shares.

According to SINAB (2015), in 2014 the acreage under organic farming in Italy arrived at about 1.4 Mha, an increase of more than 5.4% over the previous year. This figure corresponds to 10.8% of the national utilised agricultural area (UUA) (Figure 4). The

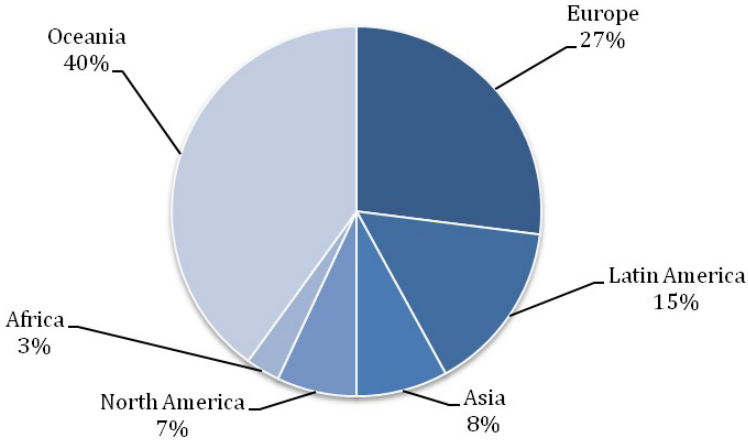

Figure 2: Percentage distribution of organic agricultural land across world (2013) (Source FIBL-IFOAM, 2015)

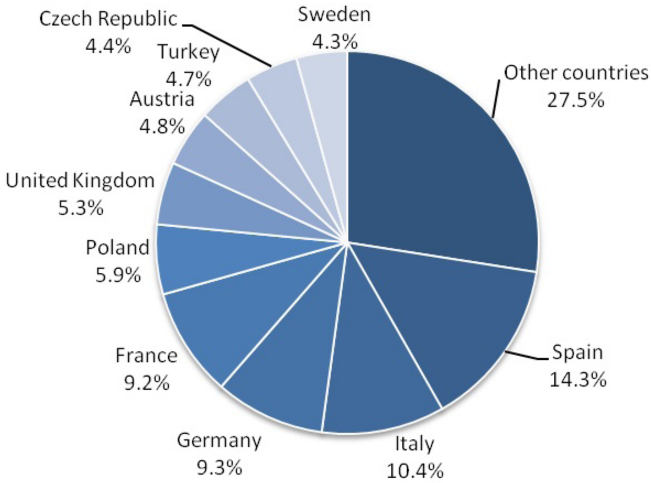

Figure 3: Percentage distribution of organic agricultural land across Europe (2013) (Source FIBL-IFOAM, 2015)

number of organic growers amount to about 46,000 farms (ISPRA, 2014). Italy is among the world's foremost producers of citrus fruits, olives, fruits (grapes, cherries, pears, plums, apples, quinces and apricots), cereals and vegetables. Moreover, Italy is at the top of the world market for the production of high quality organic jams and marmalades.

Figures provided in this paragraph confirm the growing trend of organic farms all over the world. It reflects the rising demand for healthy organic food. According to ISMEA (Institute of Services for the Food Agricultural Market) (2014), 60% of total consumers buy organic food. In 2014, there was a sharp increase of organic food consumption, both compared to 2012 (+5.8%) and compared to 2013 (+ 4.5%). These data are corroborated by a survey carried out by Nomisma (an Italian society for economic studies), and the Observatory of the International Organic and Natural (2014), according to which more than 50% of Italians said they had purchased organic products over the year. As reported by a survey of the Institute of Services for the Agricultural and Food Market (ISMEA, 2014) and by the National Information System on Organic Agriculture (SINAB, 2014), the Italian organic market continues to grow at a fast pace. In the first five months of 2014, the consumption of packaged organic products in supermarkets increased by 17% in value over the first five months of previous year, while overall spending on agri-food has decreased (-1.4%).

Coldiretti, the Italian leading farmers' association, estimates that in 2014 sales of organic produces totalled approximately 3.5 billion Euros, equivalent to more than 2% of the country's total food sales. In

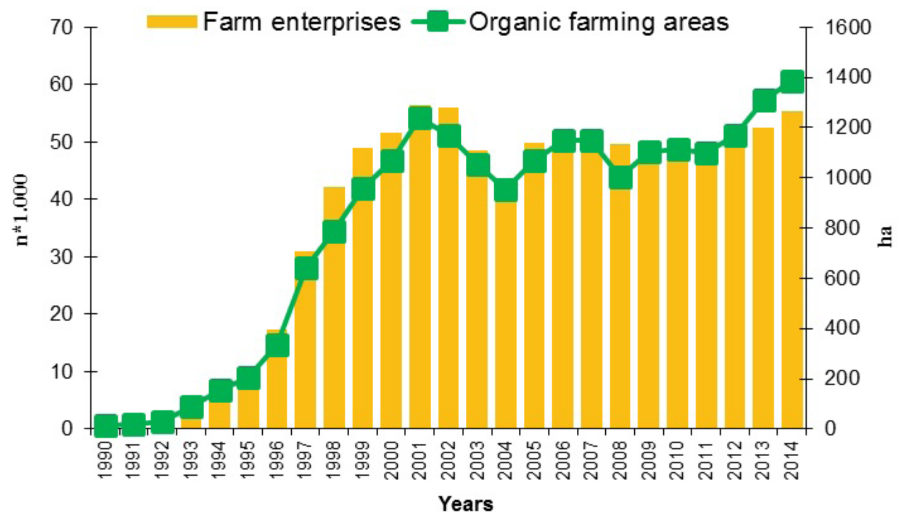

Figure 4: Trend of total organic farming areas (UAA) in Italy and of number of farm enterprises (source SINAB, 2015)

comparison with 2013, the biggest increases were for pasta, rice and bread (+73%), sugar, coffee and tea (+37.2%), biscuits, sweets and snacks (+15.1%), followed by fresh fruit and vegetables and processed (up 11%) and dairy products (+ 3.2%), eggs (+5.2%) and organic beverages (+2.5%). This data corroborates with those released from the Italian Association for Organic Agriculture (AIAB) on the steady growth of organic food compared to a decrease in conventional food consumption.

The success of organic farming indicates a growing awareness of food issues in Italy, by showing a strong tendency toward a more healthy, environmentally sustainable and natural lifestyle, even in inhabitants of cities. Organic also represents the possibility to feed children and unhealthy individuals in a more healthy and safe way; unfortunately, the higher price of organic products is still the main factor in limiting its proliferation. Despite this framework, organic farming seems to have all the requisites to respond to future environmental challenges and to the need of the Italian families (FIRAB, 2013).

Organic food, health and nutrition

It is widely considered that organic food has a better quality from a nutritional point of view when compared with food produced using traditional production techniques. This conclusion also comes from a report prepared by the Council for Research in Agriculture and Agricultural Economic Analysis (CRA, 2012). The report examined the scientific literature published in recent years on the relationship between nutritional value and organic production. What emerged from this analysis is that the quality of food is not only related to production practices, but also to the genetic characteristics of the product and those of the site, such as soil quality and climate type.

For instance, with regard to cereals, differences were observed between organic and conventional products concerning the total proteins, where products from conventional farming have higher values. This result may be explained by the large use of nitrogen-based fertilizers usually present in the conventional agriculture.

In fruits, studies showed in some cases a higher concentration of ascorbic acid in organic products. Furthermore, it is interesting to note that in a significant number of studies the average weight of fruit specimen is lower than that measured in fruits from conventional farming; this could be explained by the general lower yield per area unit of organic farming compared to conventional farming. For fruits, it was not possible to highlight significant differences in minerals and vitamins between the two cropping methods. Organic products presented higher concentrations of antioxidant compounds, such as phenols (considered beneficial for human health), than fruits produced using conventional

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Table 1: Summary of nutritional study results, comparing organic and non-organic category of products (Source CRA 2012)

Component/ Product category	**CEREALS**	**FRUITS**	**VEGATABLES**	**MILK**
Weight		-		
Dry matter			=	
Soluble solids		= / +	+ / =	
Acidity		+ / =		
Sugars	+ / -		=	=
Proteins	-			=
Minerals		=	=	
Ascorbic acid		+	=	
Phenolic compounds *		=	=	
Carotens		=	+ / =	
Antioxidant capability		+ / =	=	
Total fats				=
Saturated fatty acids				=
Monounsaturated fatty acids				=
Linoleic acid				=
Linolenic acid				+
CLA				+

Where:
(+) means a difference in favour of the organic
(-) means a difference in favour of conventional
(=) indicates no differences
* In small fruits (raspberry, strawberry and blueberry) phenolic compounds, kaempferol and ellagic acid, were more present in organic products than in those deriving from conventional agriculture.

farming methods. Conversely, in tomatoes, potatoes and peppers, which also represent the most studied vegetables, there were no significant differences of antioxidant compounds, sugars and carotenoids, between the two farming methods.

However, for milk and dairy products, the limited studies available did not show significant differences in the content of vitamins A and E. Similarly, detailed data about the differences in total protein content, lactose and fat, between organic and conventional are missing. An important research outcome was that organic milk has a high ratio of omega-3 rather than omega-6 essential fatty acids (EFA). The ratio of omega-6 to omega-3 essential fatty acids (EFA) represents an important nutritional factor in milk. Several sources of information suggest that in Western diets the ratio of omega-6 to omega-3 essential fatty acids (EFA) has evolved from approximately 1/1 to 15/1-16.7/1, which means that are de-

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ficient in omega-3 EFA. This imbalance is assumed to be one of the important causes for cardiovascular disease and of some of cancers and auto-immune inflammatory diseases.

The conjugated linoleic acid (CLA in short) was found in higher concentrations in organic milk, demonstrating that feed quality, in this case forage, represents a crucial factor affecting the nutritional characteristics of milk and dairy. The content of saturated and monounsaturated fatty acids is rather similar in both types of products examined (organic and conventional). The main findings of the whole comparative study are summarized in Table 1.

It is important to observe that for products such as oil, meat and eggs, there is no statistically significant information yet, mainly because the scarcity of studies carried out.

An article published in the Time magazine thoroughly analyses the pros and cons of organic food, especially in terms of nutritional value (Kluger 2010). The study supports the idea of the superiority of organic, especially for animal products such as milk, meat and eggs. In this case, animals are free to graze and fed with forage and cereals, rather than feed from various sources; this may improve the nutritional value of meat, giving a greater supply of nutrients and lower fat content, with obvious advantages for consumer health. Organic fruit and vegetables, however, according to the same article, pose nutritional characteristics very similar to those of conventional products. To confirm this, Hoefkens et al. (2010) maintain that there are no significant differences between organic and conventional fruit and vegetables in terms of vitamins and other nutritional factors.

Organic farming and use of environmental resources

Studies carried out on different farming methods point out that organic agriculture is characterized by reduced impact on all abiotic (such as air, soil and water) and biotic (flora and fauna) environmental components, compared to conventional methods. The most important benefits deriving from the use of sustainable and biocompatible agricultural management are:

- Reduced demand for fossil energy; organic farming needs on average 30% less energy per unit of product, thanks to the use of low impact means and techniques and of very short sales chains, preferentially at local level (zero km products)
- Lower water consumption; non-intensive production, combined with the use of only organic fertilization and specific cultivation practices as green manure application, favour the accumulation of organic matter in soil, essential for improving the efficiency of plant growth and for the effectively retaining groundwater
- Organic crops are not treated with synthetic pesticides and fungicides; so biological management practices favour the natural self-defence of the plant. For this, healthy and uncontaminated soil is an important prerequisite. A series of interventions aimed at improving soil fertility and plant resistance to pathogens and environmental stresses are performed, in the full safeguard of existing ecosystems and limiting residues of pesticides and fungicides products in the environment.

Recent studies indicate that soil cultivated with organic farming techniques may be characterised by an average yield of about 20-25% lower, compared to soils cultivated through conventional intensive methods (Mondelaers et al., 2009; Tuomisto et al., 2012). This means that to achieve the same production of conventional agriculture, it whould be necessary to cultivate, in the case of biological, a soil extension of 20% greater. The average yields for organic fruits are lower than 3% of the conventional one, while it is observed a 10% average drop in yield for oil seeds; cereals and vegetables show an average yield loss of about 25% and 35% respectively. This would be attributed to a lower availability of nitrogen and phosphorus, especially in certain types of soils when they are not enriched with massive quantities of high nitrogen content chemical fertilizers which is on the contruary done in the case of conventional agriculture.

The lower demand of energy input, water and chemicals, together with a higher guarantee of long-term productivity of soils, however, could compensate, at least in part, the lower yield of this type of production. This issue, however, may represent a significant

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limit for organic farming, especially in some territorial contexts, given the growing scarcity of space and soils that can be devoted to food production.

Organic farming and climate change

The relationship between agriculture and climate change is very complex and multi-faceted. Climate change will have significant and generally negative impacts on agriculture and growth prospects in the lower latitudes. Over the last three decades, climate change is estimated to have reduced global yields of maize and wheat by 3.8 and 5.5%, respectively, relative to a counter-factual without rainfall and temperature trends. By 2050, climate-related increases in water stress are expected to affect land areas twice the size of those areas that will experience decreased water stress. Climate variability in the coming decades will increase the frequency and severity of floods and droughts, and will increase production risks for both crop-producers and livestock keepers and reduce their coping ability. Climate change poses a threat to food access for both rural and urban populations, by reducing agricultural incomes, increasing risk and disrupting markets. Resource-poor producers, landless and marginalized ethnic groups are at particular risk.

Secondly, while most green-house gas (GHG) emissions can be traced to fossil fuel use for energy, agriculture also plays a key role. Agricultural soils contribute to methane emissions, carbon dioxide and nitrous oxide. A relatively new GHG threat is nitrous oxide, which occurs naturally, but has increased markedly as a result of the growing use of synthetic fertilizers (which are not allowed in organic farming). According to a study carried out by Tubiello et al. (2015), refining the information available through the PCC AR5 (WGIII Section 11.2.3), global GHG emissions from agriculture reached 5.4 Gt CO_2 eq in 2012, or 11.2 ± 0.4% of total GHG emissions, roughly 1% more than the previous year.

Agriculture, (mostly because the massive increase in the number of ruminants,) accounts for about 47% of annual global anthropogenic emissions of methane. The concentration of these emissions in the atmosphere has increased by a factor of 2.5 since preindustrial times, from 722 parts per billion to about 1850 ppb. Production of methane in the soil is also associated with the anaerobic decomposition of organic matter. Because of this, the main anthropogenic source of soil-derived methane is rice (Oryza sativa L.) production. Natural soil-derived methane comes mainly from wetlands.

The main source of GHG emissions is the enteric fermentation of ruminants, due to the natural gas that is produced during the digestion of food, which alone totals 39% of the entire agricultural sector. This source follows the distribution of synthetic fertilizers: 13% of agricultural emissions (about 725 Mt CO_2 eq.). Even in Italy, the agricultural sector is a net emitter of greenhouse gases and contributes around 7% to the total national emissions.

The world's agro-ecosystems (croplands, grazing lands, rangelands) are depleted of their soil's organic carbon (SOC) pool by 25–75% depending on climate, soil type, and historic management. The magnitude of loss may be 10 to 50 tons C ha^{-1}. Soils with severe depletion of their SOC pool have low agronomic yield and low use efficiency of added input.

Conversion to a restorative land use and adoption of recommended management practices, can enhance the SOC pool, improve soil quality, increase agronomic productivity, advance global food security, enhance soil resilience to adapt to extreme climatic events, and mitigate climate change by off-setting fossil fuel emissions.

The technical potential of carbon (C) sequestration in soils of the agro-ecosystems is 1.2–3.1 billion tons C yr^{-1}. Improvement in soil quality, by increase in the SOC pool of 1 ton C ha-1 yr^{-1} in the root zone, can increase annual food production in developing countries by 24–32 million tons of food grains and 6–10 million tonnes of roots and tubers.

The strategy is to create positive soil C and nutrient budgets through the adoption of management practices such as no-till and reduced-till farming, use of cover crops, improved residue management and crop rotations, integrated nutrient management including bio-fertilizers, as well as the conversion of marginal cropland to native vegetation or conversion of cultivated land to permanent grassland.

In this regard, the principles of organic farming

have the potential to both reduce net greenhouse gas (GHG) emissions and to serve as a direct carbon sink through SOC sequestration. Organic farming may enhance soil quality, generating vital regulating services of buffering, filtering and moderating the hydrological cycle, improving soil biodiversity and regulating the carbon, oxygen and plant nutrient cycles, enhancing resilience to drought and flooding, and carbon sequestration (Crowder et al., 2010; Gattinger et al., 2012; Kennedy et al., 2013).
A possible path could be the use of crop varieties and livestock breeds with a high ratio of productivity when using externally-derived inputs. This would avoid the unnecessary use of external inputs, harnessing agro-ecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism, minimising the use of technologies or practices that have adverse impacts on the environment and human health.

According to data published by the Rodale Institute (2011), organic farming systems use 45% less energy than conventional ones and use energy more efficiently, producing 40% less GHGs than agriculture based on conventional methods. Organic soils thus have a role of carbon sink, which is on average estimated at 0.5 tonnes C ha-1 yr-1. In this sense, organic farming provides farmers with significant options both in the policies of mitigation and adaptation to climate change.

Conclusions

There is ample scientific evidence on the positive effects of organic farming on human health, animal welfare and on the environment sensu lato when compared to conventional farming. In fact, organic farming has positive impacts on externalities such as conservation of biodiversity, GHG emissions reduction and carbon sequestration, energy efficiency, clean water availability, nutrient cycling, flood protection, groundwater recharge, and landscape amenity value. There is also growing evidence from landscape-scale studies that greater proportions of land devoted to organic and diversified techniques enhance ecosystem services such as pest control and pollination on farms.

Scientific evidence considers that conventional agricultural systems give higher levels of productivity per unit area, thus it is preferable to organic for meeting food security.

However, in comparing organic and conventional farming with respect to food security, it should be noted the notion of food security encompasses not only the concept of sufficiency, but also the concepts of health and nutritional value. In fact, according to the official definition of the World Health Organisation (1996), food security is reached when "... all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food their preferences for an active and healthy life."

In addition, soils subjected to intensive forms of agriculture are susceptible to a decline in fertility and production capacity in the short- and medium-term, thus undermining the potential future production. Recent studies have estimated that nearly 40% of intensively cultivated land will be lost by 2050. Land cultivated organically, on the contrary, tends to retain the physical, chemical and biological properties over the long timeframe, while maintaining stable levels of productivity and not escalating land occupation from other land uses.

While admitting that productivity is an important parameter, sustainability cannot be measured in terms of tonnes of food per hectare. The dominant traditional farming systems have provided growing stocks of food or wood or fibre, but often at the expense of other objectives of sustainability: environmental degradation, public health problems, the loss of crop varieties and genetic biodiversity.

The productivity shortcoming of organic crops may be worked out by further investment in research and in improving organic and diversified farming techniques, culpably underfunded in comparison to conventional techniques. Encouragingly, the few long-term studies that have been conducted have demonstrated that diversification techniques improve yields while enhancing ecosystem services, profitability and stability.

Whether organic agriculture can continue to expand and increase its capacity to feed the world will primarily be determined by whether it is economically competitive with conventional agriculture.

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In this respect, a meta-analysis was carried out by Reganold and Wachter (2016), examining the financial performance of organic and conventional agriculture of a global dataset spanning 55 crops grown on five continents. It showed that when organic subsidies were not applied, benefit/cost ratios and net present values of organic agriculture were significantly lower than conventional agriculture. However, when actual subsidies were applied, organic agriculture was significantly more profitable and had higher benefit/cost ratios than conventional agriculture. The study accounted for neither environmental costs (negative externalities) nor ecosystem services from good farming practices, which likely favour organic agriculture. This suggests that organic agriculture can continue to expand even if premiums decline.

The strategic direction of the future of organic farming should be the integration of conventional and organic agriculture, combining the synergistic aspects of both systems, thus achieving good yields of high quality products, and embracing the concept of the sustainable intensification of agriculture and 'climate smart agriculture' approaches (Campbell et al., 2014).

Finally, although organic agriculture has a key and compelling role in creating sustainable agricultural systems, it is important to keep in mind that no single approach can alone resolve food security. Rather, it needs a combination of organic and other innovative alternative farming systems, like agroforestry, agro-ecology, integrated farming, conservation agriculture and intercropping. Conventional farmers have the challenge of maintaining soil productivity in the long run, without making massive use of synthetic fertilizers, pesticides and fungicides, but rather through crop rotation and the addition of organic matter, thus recovering the missing nutrients in the soil itself and also safeguarding the biodiversity in agro-ecosystems.

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Conflict of Interests

The authors hereby declare that there is no conflict of interests.

References

Campbell, B. M., Thornton, P., Zougmore, R., Asten, Piet van and Lipper, L. (2014). Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability, 8*, 39–43

Ciccarese, L., Silli, V. (2014). *FOCUS - L'agricoltura bio. Un caso di successo italiano a tutela della biodiversità. Annuario dei dati ambientali 2014*. (pp. 37-52). ISPRA, ISBN 978-88-448-0662-0

CRA (2012). *La qualità nutrizionale dei prodotti dell'agricoltura biologica. Risultati di un'indagine bibliografica (2005-2011),* Roma CRA-Consiglio per la Ricerca e la sperimentazione in Agricoltura ex Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione (INRAN)

Crowder, D. W., Northfield, T. D., Strand, M. R. & Snyder, W. E. (2010). Organic agriculture promotes evenness and natural pest control. *Nature 466*, 109–112

Dawea, D., & Maltsogloub, I. (2014). Marketing margins and the welfare analysis of food price shocks. *Food Policy, 46*, 50–55

FAO (2015). *Climate change and food systems: global assessments and implications for food security and trade*. Elbehri A., ed. Food Agriculture Organization of the United Nations (FAO), Rome.

FIBL- IFOAM (2015). The World of Organic Agriculture. Statistics and Emerging. Trends 2015. Willer, H. W. & Lernoud J. (Eds.). *FiBL-IFOAM Report*. ISBN FiBL 978-3-03736-271-6, ISBN IFOAM 978-3-944372-12-9

FIRAB (2013). + BIO: LE CHIAVI DEL SUCCESSO Analisi su offerta, domanda e tendenze del mercato Bio, in Italia e nel Mondo, Pietromarchi, A. (Eds), *AIAB 1988-2013, 25 anni di buon biologico italiano,* retrieved from *http://www.firab.it/site/piu-bio-in-italia-le-chiavi-del-successo/*

Gattinger A, Muller A, Haeni M, Skinner C, Fliessbach A, Buchmann N, Mader P, Stolze M, Smith P, Scialabba NEH. & Niggli U (2012) Enhanced top soil carbon stocks under organic farming. *Proceedings of the National Academy of Sciences of the United States of America 109*, 18226–18231.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., & Toulmin C. 2010. Food Security: The Challenge of Feeding 9 Billion People. *Science 327*, 812 doi: 10.1126/science.1185383

Hoefkens Ch., Sioen I., Baert K., De Meulenaer B., De Henauw S., Vandekinderen I., Devlieghere F., Opsomer A., Verbeke W. & Van Camp J., 2010. Consuming organic versus conventional vegetables: The effect on nutrient and contaminant intakes. *Food Chem. Toxic. 48*, 3058-3066

Hole, D. G., Perkins, A. J., Wilson, J. D., Alexander, I. H., Grice, P. V. & Evans A. D. (2005). Does organic farming benefit biodiversity? *Biological Conservation, 122*, 113–130

ISMEA. (2014). *Report Prodotti biologici. Osservatorio sul mercato dei prodotti biologici n. 2/14 – 5 Maggio 2014.* News mercati - Prodotti biologici. ISMEA, retrieved from *http://www.ismea.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/8907*

ISPRA (2014). *Annuario dei dati ambientali 2014. Focus L'agricoltura bio. Un caso di successo italiano a tutela della biodiversità. Annuario dei Dati Ambientali 2013*, 37-52. ISPRA, ISBN 978-88-448-0662-0

Kennedy CM, Lonsdorf E, Neel MC, Williams NM, Ricketts TH, Winfree R, Bommarco R, Brittain C, Burley AL, Cariveau D, Carvalheiro LG, Chacoff NP, Cunningham SA, Danforth BN, Dudenhöffer J-H, Elle E, Gaines HR, Garibaldi LA, Gratton C, Holzschuh A, Isaacs R, Javorek SK, Jha S, Klein AM, Krewenka K, Mandelik Y, Mayfield MM, Morandin L, Neame LA, Otieno M, Park M, Potts SG, Rundlöf M, Saez A, Steffan-Dewenter I, Taki H, Viana BF, Westphal C, Wilson JK, Greenleaf SS. & Kremen C. (2013). A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecology Letters 16(5)*:584-599

Kirchmann, H. & Thorvaldsson, G. (2000). Challenging targets for future agriculture, *European Journal of Agronomy 12 (3-4)*, 145–161

Tubiello, F. N., Salvatore, M., Ferrara, A. F., House, J., Federici, S., Rossi, S., Biancalani, R., Condor Golec, R. D., Jacobs, H., Flammini, A., Prosperi, P., Cardenas-Galindo, P., Schmidhuber, J., Sanz Sanchez, M. J., Srivastava, N., & Smith, P. (2015). The contribution of agriculture, forestry and other land use activities to global warming, 1990-2012, *Glob Chang Biol, Jan 10*. doi: 10.1111/gcb.12865.

Kluger J. (2010). What's So Great About Organic Food? *TIME*, September 6, 2010, 4-39

Maes, J., Paracchin, M. L., Zulian, G., Dunbar, M. B. & Alkemade, R. (2012). Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. *Biological Conservation, 155*, 1–12

Mondelaers, K., Aertsens, J. & Van Huylenbroeck, G. (2009). A meta-analysis of the differences in environmental impacts between organic and conventional farming. *Br Food J, 111*, 1098–1119.

Parrott, N., Olesen, J. E. & Høgh-Jensen, H. (2006). certified and uncertified organic farming in the developing world. In, Halberg, N., Alroe, H. F., & Knudsen, M. T. *Global Development of Organic Agriculture: Challenges and Prospects*. UK: CABI, pp. 153–179

Ponisio, L. C. & Kremen, C. (2016). System-level approach needed to evaluate the transition to more sustainable agriculture. P*roc. R. Soc. B, 283: 20152913*, *http://dx.doi.org/10.1098/rspb.2015.2913*

Porter, J., Costanza, R., Sandhu, H., Sigsgaard, L. & Wratten, S. (2009). The value of producing food, energy, and ecosystem services within an agro-ecosystem. *Ambio, 38*, 186–193

Prihtanti, T. M., Hardyastuti, S., Hartono, S. & Irham (2014). Social-cultural functions of rice farming systems. *Asian J. Agr Rural Dev, 4*, 341–351

Rodale Institute (2011). *The Farming System Trials. Celebrating 30 Year*. Rodale Institute, retrieved from *http://66.147.244.123/~rodalein/wp-content/uploads/2012/12/FSTbookletFINAL.pdf*

SINAB (2014). *Bio in cifre 2014*. SINAB, retrieved from *http://www.sinab.it/sites/default/files/share/bio%20in%20cifre%202014_7.pdf*

SINAB (2015). *L'agricoltura biologica in cifre al 31/12/2014* – anticipazioni. SINAB, retrieved from *http://www.sinab.it/sites/default/files/share/anticipazioni%20dati%202014%20rev3.pdf*

Skinner, C., Gattinger, A., Muller, A., Mäder, P. Flieβbach, A., Stolze, M., Niggli, U. (2014). Greenhouse gas fluxes from agricultural soils under organicand non-organic management - a global meta-analysis. *Science of Total Environment, 468–469*, 553–563

Steffen, W. Richardson, K. Rockström, J. Cornell, S.E. Fetzer, I. Bennett, E.M. Biggs, R. Carpenter, S.R. de Vries, W. & de Wit, C.A (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, (347) 663. doi: 10.1126/science.1259855

United Nations (2015). *MDGs - Millennium Development Goals*. ISBN 978-92-1-101320-7

Tuomisto, H. L., Hodge, I. D., Riordan, P. & Macdonald D. W. (2012). Does organic farming reduce environmental impacts? – A meta-analysis of European research. *Journal of Environmental Management, 112*, 309–320

Vanloqueren, G. & Baret, P. V. (2009). How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. *Res. Policy, 38*, 971-983. doi: 10.1016/j.respol.2009.02.008

Waggoner P. (1997). *How Much Land Can Ten Billion People Spare for Nature. Technological Trajectories and the Human Environment*. National Academy Press, (pp. 56-73), Washington DC