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3 Current developments in organic farming

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Abstract

Organic farming uses almost exclusively biological and natural materials and processes to produce food. The practice aims to protect human health and conserve, maintain or enhance natural resources, with the goal to preserve the quality of the environment for future generations while being economically sustainable. Organic farming has grown rapidly throughout the world in recent years. Currently, Australia (Oceania) has the largest land areas under organic farming, Liechtenstein (Europe) the highest percentage of organic area, and Mexico (Latin America) the greatest number of organic farms worldwide. One of the most valuable benefits of

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organic farming is the improvement in soil quality, which can be expressed in terms of chemical, physical and biological properties and their interactions. In this article, we will discuss the properties, regulations and impacts of organic farming on human livelihood and the environment.

Overview of organic farming

Organic farming has expanded rapidly in recent years and is seen as a sustainable alternative to chemical-based agricultural systems (Stockdale *et al*., 2001; Biao *et al*., 2003; Avery, 2007). Its annual growth rate has been about 20% for the last decade (Lotter, 2003), accounting for over 31 million hectares (ha) and generating over 26 billion US dollars in annual trade worldwide (Yussefi, 2006). Nutrient management in organic farming systems is often based on soil fertility building via nitrogen (N) fixation and nutrient recycling of organic materials, such as farmyard manure and crop residues, with limited inputs from permitted fertilizers (Gosling and Shepherd, 2005). Although organic farming has been criticized for relying on the build-up of soil phosphorus (P) and potassium (K) by past fertilization before converting to organic (Nguyen *et al*., 1995; Greenland, 2000; Løes and Øgaard, 2001), its acceptance and popularity are growing due mostly to environmental and health-related concerns (Biao *et al*., 2003; Galantini and Rosell, 2006). A recent polling of residents of Ontario, Canada reveals that more than half think organic food is more nutritious; two-thirds believe organic food is safer than conventionally grown food; and 9 out of 10 believe organic fruits and vegetables are grown without pesticides of any kind (Avery, 2007).

The aims and principles of organic farming, as presented in the International Federation of Organic Agriculture Movements (IFOAM) Basic Standards for production and processing are listed in Table 1.

A shift to organic agriculture brings about significant changes: restricted use of synthetic fertilizers and pesticides, increases of other inputs such as organic materials, labor, perhaps machinery, cultural practices (e.g., crop rotation), and better knowledge of biological processes. These changes have serious implications. Thus, farmers should consider the following issues before practicing organics (FAO, 1998):

*** Labor inputs:** Labor is important to the production process, and can be an impediment to the adoption of organic agriculture. Compared to large-scale mechanized agricultural systems, organic farming appears more labor-intensive. Many techniques used in organic farming require significant labor (e.g., strip farming, non-chemical weeding, composting). In the developed

Table 1. The principal aims of organic production and processing (IFOAM, 1998).

* To produce food of high quality in sufficient quantity.
* To interact in a constructive and life-enhancing way with natural systems and cycles.
* To consider the wider social and ecological impact of the organic production and processing system.
* To encourage and enhance biological cycles within the farming system, involving microorganisms, soil flora and fauna, plants and animals.
* To develop a valuable and sustainable aquatic ecosystem.
* To maintain and increase long-term fertility of soils.
* To maintain the genetic diversity of the production system and its surroundings, including the protection of plant and wildlife habitats.
* To promote the healthy use and proper care of water, water resources and all life therein.
* To use, as far as possible, renewable resources in locally organized production systems.
* To create a harmonious balance between crop production and animal husbandry.
* To give all livestock conditions of life with due consideration for the basic aspects of their innate behavior.
* To minimize all forms of pollution.
* To process organic products using renewable resources.
* To produce fully biodegradable organic products.
* To produce textiles which are long lasting and good quality.
* To allow everyone involved in organic production and processing a quality of life that meets their basic needs and allows an adequate return and satisfaction from their work, including a safe working environment.
* To progress toward an entire production, processing and distribution chain which is both socially just and ecologically responsible.

world, labor scarcity and costs may deter farmers from adopting organic systems. This may also be true for cash-poor farmers and those supplementing their incomes with off-farm work. However, where labor is not a constraint, organic agriculture can provide employment opportunities, especially in rural communities. Furthermore, the diversification of crops typically found on organic farms, with their various planting and harvesting schedules, may result in more work opportunities for women and a more evenly distributed labor demand which helps stabilize employment.

* **Other production-related inputs:** The absence of synthetic fertilizers and pesticides in organic farming necessitates other inputs from manure addition to crop selection or irrigation. Farmers' knowledge of local conditions and of traditional practices is essential to the success of organic farming. The emphasis of crop varieties and animal breeds used in organic agriculture is on local suitability with respect to disease resistance and adaptability to local climate.

* **Crop rotation:** This operation is required under organic certification programs and is considered essential in organic management. Agricultural pests are often specific to the host (i.e., a particular crop), and will multiply as long as the crop is there. Alternating crops in time (rotations) or space (strip-cropping and intercropping) is therefore an important tool for controlling pests, and also for maintaining soil fertility. As the use of synthetic fertilizers and pesticides allows the farmer to grow the crop that is financially most rewarding, not using those inputs may limit the choice of crops. The success of an organic farm depends on the identification of end-uses and/or markets for all the crops in the rotation, as few farmers can afford to leave fields fallow. This remains one of the most significant challenges in organic agriculture.

* **Yield:** Yields on organic farms, although may not be as high as those produced by conventional practices, fall within an acceptable range (Avery, 2007). Encouragingly, organically produced yields currently are significantly higher than those produced before the 1950s. Part of this progress can be attributed to new varieties and better knowledge of biological processes used in farming. For example, if N mineralization is slow because of cool/wet growing-conditions, crops on organic farms may not have sufficient N early in the season. However, better knowledge on N synchronization between N release by manures and N demand by crops could minimize or even eliminate this N deficiency problem (Hue and Silva, 2000; Myers *et al*., 1997).

Definition of organic farming

There are many definitions of organic farming, which is also known as ecological agriculture (Gosling *et al*., 2006) or biodynamic agriculture (Lampkin, 2002). Some have considered organic farming and sustainable agriculture synonymous, because they are both based on sustainability of agro-ecological systems. Sustainability can be defined as meeting the need of the present without compromising the ability of future generations (WCED, 1987). The word "organic" is legally protected in some countries, avoiding their indiscriminate use in non-organic products. In the European Union (EU), for example, this word has been protected since the early 1990s in English-speaking countries. The equivalent in French, Italian, Portuguese and Dutch-speaking countries is "biological", and "ecological" in Danish, German and Spanish-speaking countries (FAO, 1998).

Organic farming according to Henning *et al*. (1991) is both a philosophy and a system of farming, grounded in values that reflect an awareness of ecological and social realities and the ability of the individual to take effective actions. In practice, it is designed to work with natural processes to conserve resources, encourage self-regulation through diversity, to minimize waste and environmental impacts, while preserving farm profitability.

According to Lampkin (1994, 1997), the aim of organic farming is: "to create integrated, humane, environmentally and economically sustainable production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and disease, and an appropriate return to the human and other resources". As such, organic farming shares the fundamental objectives of agricultural sustainability and is deserved to be assessed as a mainstream part of sustainable agriculture (Edward-Jones and Howells, 2001). IFOAM (2000) has defined organic agriculture as "a process that develops a viable and sustainable agro ecosystem". In practical terms, organic farming is a form of agriculture that shies away from synthetic inputs such as pesticides and fertilizers (because of their negative effects on the ecological balance) but uses agricultural practices such as crop rotation, proper spacing between plants, incorporation of organic matter into the soil, and composting (Kuo et al., 2004). With restrictions on the use of chemical fertilizers, the principal challenge to converting a conventional farm to an organic one is to provide N, K (because these two elements are required at rather large quantities by most crops and because they are easily leached from soils), and to a lesser extent, other plant nutrients at rates and times to ensure acceptable crop yields (Rodrigues *et al.*, 2006; Hue and Silva, 2000).

Production requirements in organic farming

While conventional farming needs abundant, man-made resources, organic farming makes use of functional integrity of the system (Boelling *et al.*, 2003). Organic farming depends on the local environment (soil, water) and less powerful tools (heavy equipment).

Although the exact production methods vary, general principles include the exclusion of most synthetic biocides and fertilizers, the management of soils through addition of organic materials and use of crop rotation (IFOAM, 1998). The requirements (which apply to the way the product is created, not to the measurable properties of the product itself) by the USDA National Organic Program (NOP) are summarized as follows (NOP, 2006).

Crop requirements

* Land will have no prohibited substances applied to it for at least 3 years before the harvest of an organic crop.
* The use of genetic engineering (included in excluded methods), ionizing radiation and sewage sludge is prohibited.

* Soil fertility and crop nutrients will be managed through tillage and cultivation practices, crop rotations, and cover crops, supplemented with animal and crop waste materials and allowed synthetic materials.
* Preference will be given to the use of organic seeds and other planting stock, but a farmer may use non-organic seeds and planting stock under specified conditions.
* Crop pests, weeds, and diseases will be controlled primarily through management practices including physical, mechanical, and biological controls.
* When these practices are not sufficient, a biological, botanical, or synthetic substance approved for use on the National List may be used.

Livestock requirements

* Animals for slaughter must be raised under organic management from the last third of gestation, or no later than the second day of life for poultry.
* Producers are required to feed livestock agricultural feed products that are 100 percent organic, but may also provide allowed vitamin and mineral supplements.
* Producers may convert an entire, distinct dairy herd to organic production by providing 80 percent organically produced feed for 9 months, followed by 3 months of 100 percent organically produced feed.
* Organically raised animals may not be given hormones to promote growth, or antibiotics for any reason.
* Preventive management practices, including the use of vaccines, will be used to keep animals healthy.
* Producers are prohibited from withholding treatment from a sick or injured animal; however, animals treated with a prohibited medication may not be sold as organic.
* All organically raised animals must have access to the outdoors, including access to pasture for ruminants. They may be temporarily confined only for reasons of health, safety, the animal's stage of production, or to protect soil or water quality.

The absence of soluble chemical fertilizers and the limited use of natural biocides in organic agriculture mean that it is largely dependent on biological processes for the supply of nutrients (e.g., N_2 fixation), and for protection of crops from pests and disease (Gosling, *et al*., 2006). Organic manures could provide essential nutrients to crops but, if not properly managed, may also promote N losses by denitrification (Smith and Chambers, 1993) and ammonia volatilization (Holding, 1982). Arbuscular mycorrhizal fungi (AMF) can be used to enhance P uptake. Biocontrol agents that may be used in organic systems to control pathogenic fungi do not appear to damage the AMF association (Ravnskov *et al*., 2002; Gaur *et al*., 2004). Fine green sands and feldspars, which are natural minerals, could provide K (Hue and Silva, 2000). Neem (*Azadirachta indica* A.) extract could be use as a biocide; also the introduction or augmentation of predators or parasites of pests can be implemented for pest control.

Despite the potentially adverse effect of tillage on soil quality and the high cost of tillage operations, tillage forms an important part of weed control strategies in organic systems (Bond and Grundy, 2001). That is because low or no-till can result in an increase in perennial weed numbers, which are difficult to control in the absence of herbicides (Kuowenhoven *et al*., 2002; Torresen *et al*., 2003; Håkansson, 2003). Thus, there is a limit to which tillage can be reduced in organic systems while maintaining adequate weed control. Alternatively, mulching with fully biodegradable materials, where possible, is encouraged in organic production.

Regulations in organic farming

Factors that are used to classify organic farming may partly vary with local circumstances in terms of needs and availability of resources. In countries where organic farming is not widely adopted, and where no organic seedlings are available, seedlings originating in conventionally managed enterprises may be used on an interim basis (Khristiansen and Merfield, 2006). Similarly, in such situations, manure may not always be available from organic farms, and sourcing it from conventional farms may sometimes be allowed. The certification of the production process at the farm level, as opposed to product certification, is specifically chosen to ensure that organic products are indeed grown according to organic standards. The task is complicated because it includes ascertainment that the farmer has incorporated a number of practices to cope with soil fertility and pests, as appropriate, in the particular area where the farm is located (FAO, 1998; NOP, 2006).

Many organizations or countries have their own certification standards, which need to be at the same level or stricter than the IFOAM's guidelines. In total, more than 100 national or regional standards have been developed, some of them in developing countries, particularly in Latin America.

Certification can be carried out by an organization outside the country, especially if no national standards for organic agriculture are available, and no local certifying organization exists. Developing countries in particular make use of this possibility, as setting up the infrastructure needed for certification of organic products (standards, inspection scheme, ratification, appeal procedures, etc.) can be costly, and is seldom self-financing, especially in the early stages. In the early days of organic certification, traders found it sometimes difficult to know which schemes genuinely certified organic produce. IFOAM has developed an accreditation program, which evaluates certification schemes and hence assists both the traders and the evaluated scheme (FAO, 1998).

Organic farming regulations can be viewed in different ways. In the EU, certified organic agriculture is viewed as a long-term solution to natural resource conservation concerns, restoration of rural landscapes, and public health promotion. EU countries provide direct and indirect aid to certified organic production, and as of 2004, had formed a European Action Plan for Organic Agriculture (Gomez-Tovar *et al*., 2005). The recent use of policy by the EU to develop more environmentally sensitive farming practices has led to a widespread interest in organic farming (van Diepeningen *et al*., 2006).

Mexico, in contrast, has viewed certified organic agriculture as a short-term solution to export and foreign exchange concerns. International buyers introduced the concept of organic certification into Central American countries. At first, farmers followed the instructions necessary to fulfill the certification requirements without a clear understanding of the certification process itself. To them, organic certification was just another rule imposed by the “first world” with cost being so high that only international buyers were able to afford (The organic standard, 2001). The major support for smallholder certification efforts has come from foreign foundations. At present, nearly a quarter of a million hectares (ha) are certified by up to 17 organic certification agencies, mostly foreign, operating in Mexico and by the Mexican National Certifier (Certimex) that has been formed and accredited under the Department of Agriculture’s National Organic Program. Other certifying agencies, such as MayaCert in Guatemala, Eco-Logica and AINCOPOP in Costa Rica and CENIPAE in Nicaragua were initiated. These organizations later joined efforts with other certification agencies from South America, which were IncaCert (Peru), Biopacha (Bolivia) and BioMuisca (Colombia), to form a Latin American Organic Certification body called BIOLATINA. These agencies offer producers such benefits as lower certification cost and clearer communication, making organic certification more accessible to small producers. This has helped shift the certification authority/responsibility from buyers to producers, giving producers the full right to choose their own buyer (The organic standard, 2001).

In the United States of America (US), the USDA National Organic Standards are in effect since 2002 (NOP, 2006) and there is a national list of substances approved for or prohibited from use in organic production and handling (USDA, 2000). To earn certification, organic farms must: a) have long term soil management plans, b) establish buffers between their fields and nearby conventional farms, c) meet specific requirements for labeling and record keeping d) use only allowed substances (see *Production Requirements*), e) keep detailed records of all the materials used in their farming operations (NOP, 2006). The products from a certified farm can then be sold as "100% organic" where all ingredients must be organically produced, "organic" where 95% of the ingredients must be organic, "more than 70% organic" and "less than 70% organic" (MAF, 2005).

In Japan, the new agricultural standards for organic products were introduced by the Japanese Ministry of Agriculture in 2000, and have been implemented since April 2001 (Shi-Ming and Sauerborn, 2006).

At present, Tunisia is the only African country with its own organic (EU compatible) standards, certification and inspection systems. Egypt and South Africa have both made significant progress in this direction, both have two certifying organizations and are well on the way to developing standards (Yussefi, 2006).

The supply of organic products has not gone hand in hand with developments on organic regulations until recently. In fact, the lack of clear organic standards and labeling in several countries has caused trouble for organic producers and consumers. Several products labeled as 'organic' and 'ecological' have been found in Canadian supermarkets yet their producers really have not followed any production standards. These incidences were threatening Canada's organic industry, and "organic fraud" is becoming a growing concern among consumers. Consequently, organic farmers in Canada have called for the food inspection agency to produce a strict set of standards and an organic seal (MAF, 2005).

Despite the government's efforts to keep a transparent market environment, New Zealand has not been exempt from the organic labeling and standards debate. A survey done by the New Zealand Food Safety Authority in 2004 (NZFSA) found more than 20% of the "organic" fruit and vegetable sampled contained chemical residues. Certification schemes in New Zealand are self regulated and only products that are exported are checked by the NZFSA for compliance (MAF, 2005).

Today, 395 organizations worldwide offer organic certification services. Most certification bodies are in Europe (160) followed by Asia (93) and North America (80). The countries with the most certification bodies are the US, Japan, China and Germany. Many of the certification organizations also operate outside of their home country. Forty percent of the certification bodies are approved by the EU, 32% have ISO 65 accreditation, and 28% are accredited under the US National Organic Program (Yussefi and Willer, 2007).

Effects on soil quality

Soil quality and its importance in sustainable agriculture have received much attention in recent years (Dumanski and Pieri, 2000; Zhang *et al*., 2003), and several lines of evidence have shown that organic farming can improve soil quality (Otutumi *et al*., 2004).

According to the Soil Science Society of America, soil quality can be defined as “the capacity of a specific kind of soil to function, within natural or managed ecosystems boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation” (SSSA, 1997). A simpler definition is “the capacity of a specific kind of soil to function” (USDA, 2001). Farmers define soil quality in terms of economy or yield outcomes (Andrews *et al*., 2003).

Soil quality influences basic soil functions (USDA, 2001). Five vital soil functions have been identified: 1) sustaining biological activity, diversity and productivity, 2) regulating and partitioning of water and solute flow, 3) filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials, 4) storing and cycling of nutrients and other elements within Earth’s biosphere, and 5) providing support of socioeconomic structures and protection for agroecological treasures associated with human habitation (Karlen *et al*., 1997). A general sequence of how to evaluate soil quality is to: (a) define the soil functions of concerns, (b) identify specific soil processes associated with those functions, and (c) identify soil properties and indicators that are sensitive enough to detect changes in the functions or soil processes of concern (Carter *et al*., 1997).

Many scientists feel that any definition of soil quality should consider its function in the ecosystem (Acton and Gregorich, 1995; Kennedy and Papendick, 1995; Warkentin, 1995; Doran *et al*., 1996; Johnson *et al*., 1997). These definitions are based on monitoring soil quality in terms of (Doran and Parkin, 1994):

* Productivity: The ability of soil to enhance plant and biological productivity.
* Environmental quality: The ability of soil to attenuate environmental contaminants, pathogens, and offsite damage.
* Animal health: The interrelationship between soil quality and plant, animal and human health.

Therefore, soil quality can be regarded as soil health (Doran *et al*., 1996). This is not a new concept. Greek and Roman philosophers were aware of the importance of soil health to agricultural prosperity over 2000 years ago, and reflected this awareness in the treatises on farm management (Liebig, 2007).

The estimation or quantification of soil quality is difficult, because a change in soil quality can only be perceived when all the effects are considered over a long period of time (Gil-Sotres *et al.*, 2005). Since the soil keeps a unique balance among its physical, chemical and biological factors, soil quality indicators should be made up of combinations of these factors. This is especially true in those situations where some integrative parameters (i.e. water infiltration rate, soil respiration) reflect simultaneous changes in soil physical, chemical and biological characteristics (Barrios *et al.*, 2006).

Soil quality indicators

Soil quality is usually considered to have three main interactive aspects: physical, chemical and biological properties and processes (Dexter, 2004; Muckel and Mausbach, 1996). The biological status of soil depends very strongly on the prevailing physical and chemical conditions (Dexter, 2004). Soil organic matter (SOM) plays a role in almost every soil function (Rivero *et al.*, 2004).

Measurements should be periodically taken over time to monitor changes or trends in soil quality and compared measured values to a standard or reference soil condition (USDA, 2001). Larson and Pierce (1994) proposed that a minimum data set of soil parameters should be adopted for assessing the health of soils, and that standardized methodologies and procedures be established to assess changes in these factors. Such indicators should be useful across a range of ecological and socio-economic situations (Lal, 1994; Doran and Parkin, 1996; Elliot, 1994; Larson and Pierce, 1991). They should:

* Correlate well with natural processes in the ecosystem (this also increases their utility in process-oriented modeling).
* Integrate soil physical, chemical, and biological properties and processes, and serve as basic inputs needed for estimation of soil properties or functions which are more difficult to measure directly.
* Be relatively easy to use under field conditions, so that both specialists and producers can use them to assess soil quality.
* Be sensitive to variations in management and climate. The indicators should be sensitive enough to reflect the influence of management and climate on long-term changes in soil quality, but not be so sensitive that they are influenced by short-term weather patterns.
* Be the components of existing soil databases where possible.

The selection of properties for use in soil quality evaluation includes physical (texture, rooting depth, infiltration rate, bulk density, water holding capacity), chemical (pH, EC, SOM, total C and N, nutrient level) and biological (C and N microbial biomass, potentially mineralizable N, soil respiration, enzymatic activities) (Sarrantonio *et al.*, 1996; Chen, 1999). The chemical tests are also useful to evaluate water quality of well-water, tile drainage waters, and other water bodies related to farm activities (USDA, 2001). In general, the physical and physicochemical parameters are often altered only when the soil undergo a rather drastic change (Filip, 2002). On the contrary, biological and biochemical parameters are sensitive to slight modifications that the soil can undergo in the presence of any degrading agent (Klein *et al*., 1985; Nannipieri *et al*., 1990; Yakovchenko *et al*., 1996). Hence, whenever the total sustainability of soil natural functions and its different uses has to be evaluated, key indicators must include biological and biochemical properties (Trasar-Cepeda *et al*., 1998; Sicardi *et al*., 2004, Melero *et al*., 2006). Attention has also been focused on both the long-term and short-term impacts of land use change on soil biological and biochemical parameters (Raiesi, 2006).

Recommended biological indicators often include (Barrios *et al*., 2006): a) bioavailable N, which is one of the keys for plant growth in agriculture. At the same time N compounds like nitrate, nitrite or N_2O play an important role in environmental pollution. Therefore, it is of great interest to understand the key process in the N cycle in more detail, to define ways for a productive agriculture that protects environment; b) microbial biomass, a measure of the total mass of soil microorganisms; c) microbial biomass to total soil carbon ratios; d) soil respiration, a sum of all CO_2 generated by biological activity in the soil; e) respiration to microbial biomass ratios; f) soil fauna populations, size and diversity of soil arthropods and invertebrates. The use of faunal groups as indicators for soil quality needs a choice of organisms that form a dominant group and occurs in all soil types, have abundance and high biodiversity, play an important role in soil functioning, e.g. food webs (Schloter *et al*., 2003). Nematodes may fulfill these conditions (Traunspruger and Drews, 1996; Freeman *et al*., 2000; Paredney and Williams, 2000; Haitzer *et al*., 1999). Use of soil faunal as indicators offers different possibilities. Single species bioassays are important to assess effects of single stressors and to bioconcentration studies (Schloter *et al*., 2003); and g) rates of litter decomposition, an integrated measure involving interaction of vegetation, soil nutrient availability, micro and macro fauna and microbial populations (Brussaard *et al*., 2004).

Caution must be exercised in using biological indicators, however. From a methodological perspective, the lack of standard analytical methods accepted by all laboratories is a fundamental problem when interpreting the values of biochemical properties. Differences in sample collection, storage, pre-treatment, protocols for determining enzymatic activities make it practically impossible to compare data obtained from different laboratories.

The use of plants to monitor soil quality has certain advantages, particularly on large scale (Madejón *et al*., 2006). Plants can exhibit the effect of soil contaminants (heavy metals, xenobiotics) on living tissues, thus revealing information on soil quality that is difficult to measure using direct soil analysis. Plants provide a direct measurement of a biological effect rather than inferring values using soil extraction. They can provide site-specific information on soil quality, as they incorporate the local environment (Wright and Welbourn, 2002).

Selected native plants frequently used by farmers as biological indicators of soil quality are listed in Table 2.

It is remarkable that quite often the same ubiquitous plants are ranked similarly by farmers in Latin America and Africa as indicators of soil quality (e.g. *Pteridium arachnoideum, Bidens pilosa and Ageratum conyzoides*), but also that species of the same genus are found in both continents indicating a similar soil quality condition (e.g. *Commelina difuca and Commelina africana*) (Barrios *et al*., 2006).

There is a need to develop soil quality indicators in such a way so that they: a) integrate soil physical, chemical and/or biological properties and processes, b) apply under diverse field conditions, c) complement either existing data bases or easily measurable data, and d) respond to land use, management practices, climate and human factors (Doran and Parkin, 1994). Selection of a minimum data set for soil quality evaluation takes into account general soil and climatic conditions for the specific agro-ecological zone and their interaction with land use (Govaerts *et al*., 2006).

Assessing soil quality is difficult, because unlike water and air quality for which standards have been established primarily by legislation, soil quality assessments are purpose-oriented and site specific (Karlen *et al*., 1994). Maintaining soil quality at a desirable level is a very complex issue due to involvement of climate, soil, plant and human factors and their interactions (Sharma *et al*., 2005).

Table 2. Native plants as local indicators of soil quality in Latin America and Africa (Adapted from Barrios *et al*., 2006).

Latin America			Soil quality[+]	Africa		
Local name	Scientific name	Botanical family		Local name	Scientific name	Botanical family
Helecho marranero	*Pteridium arachnoideum*	Pteridaceae	Poor	Mashiu	*Pteridium arachnoideum*	Pteridaceae
Mangaguasca	*Braccharis trinervis*	Compositae	Poor	Ma-shuuti	*Philippia usambarensis*	Ericaceae
Escoba Lanosa	*Andropogon bicornis*	Gramineae	Poor	Digitaria	*Digitaria sp.*	Gramineae
Siempre viva	*Commelina difusa*	Commelinaceae	Fertile	Olaiteteyai	*Commelina africana*	Commelinaceae
Papunga	*Bidens pilosa*	Compositae	Fertile	Enderepenyi	*Bidens pilosa*	Compositae
Hierba de chivo	*Ageratum conyzoides*	Compositae	Fertile	Olmalive	*Ageratum conyzoides*	Compositae

[+] When indicator plants are populated.

Soil quality improvements

Organic farming improves soil fertility over time (Clark *et al*., 1998; Petersen *et al*., 1999). In the short term (about 3 years of the transition period), organic farming may have negative effects on crop production, however. The transition period between conventional and organic farming practices is often marked by a decrease in N availability and in yields due to a shift in biological activity and N sources that are not immediately available for plant use (Petersen *et al*., 1999).

Soil biological properties. Among the benefits of organic farming is an increase in soil microbial activity and biological processes (Gunapala and Scow, 1998; Petersen et al., 1999; Scow *et al*., 1994; Werner,1997). Axelsen and Elmholt (1998) estimated that a conversion to 100% organic farming in Denmark would increase microbial biomass by 77%, the population of springtails by 37%, and the density of earthworms by 154%. A decrease in disease and parasitic nematodes has also been observed (Scow *et al*., 1994; Matsubara *et al*., 2002). Wander *et al*. (1994) studied three farming systems: (1) animal-based (cover crops and animal manure only), (2) legume based (cover crop only), and (3) conventional (N fertilizer). Their results showed that the two organic systems had higher levels of microbial activity and more diverse species than the conventional system.

Soil physical properties. Organic fertility inputs (animal and/or green manures) improve soil physical properties by lowering bulk density, increasing water-holding capacity, and improving infiltration rates (Petersen *et al*., 1999; Tester, 1990; Werner, 1997; Lee *et al*., 2006; Sadanandan and Hamza, 2006). Lower bulk density implies greater pore space and improved aeration, creating a more favorable environment for biological activity (Werner, 1997). Tester (1990) also found that amending soil with compost significantly decreased bulk density and increased soil water content.

Soil chemical properties. Organic farming increases SOM content (Alvarez *et al*., 1988; Bhat and Sujatha, 2006; Clark *et al*., 1998; Goh *et al*., 2001; Petersen *et al*., 1999; Reganold *et al*., 1993) and humic substances (Nardi *et al*., 2002). During the transition years from conventional to organic systems, most soils show a slow but steady increase in SOM (Clark *et al*., 1998; Kuo *et al*., 1997). Wander *et al*. (1994) proposed that the quality of SOM may even be more important than the quantity of SOM present in farming systems that use cover crops and other organic inputs and those that do not. Clark *et al.* (1998) found that SOM levels in the 0-30 cm depth had increased in the organic and low-input treatments by 19% after four years of organic practice. Alvarez *et al*. (1988) found a positive correlation between SOM content and available Ca, K, Mg, Na, and P. Obviously, total soil N will increase with organic practices, but extractable P and exchangeable K also often do (Alvarez *et al*., 1988; Bhat and Sujatha, 2006; Clark *et al*., 1998; Petersen *et al*., 1999; Reganold *et al*., 1993).

Perhaps because of improved soil quality, organic crops often contain more vitamin C and B-group vitamins, more phenolic compounds, and beta-carotene than conventional crops (Adam, 2001; Rembialkowska, 2004; Reganold *et al*., 2001). Sadanandan and Hamza (2006) reported that the levels of piperine and oleoresin in black pepper (*Piper nigrum* L.) were much higher in Indian fields fertilized with poultry or goat manure as compared to those receiving NPK chemical fertilizers.

Development and distribution of organic farming worldwide

Since the 1990s, organic farming has expanded considerably, especially in Europe (e.g., Germany and Scandinavia). In 1996, Austria (the only country which equates sustainable agriculture to organic agriculture) counted over 7% of its agricultural land as being under organic management, and Switzerland 6%. The Central and Eastern European countries show the same trend in growth, although the absolute rates of adoption are considerably lower (FAO, 1998).

A recent survey has shown that there are more than 31 million ha of land worldwide under organic management by at least 633,891 farms (Yussefi and Willer, 2007). Certified forest and wild harvest plants would add at least another 19.7 million ha, totaling more than 51 million ha (Yussefi, 2006). As of 2006, the countries with the greatest organic areas are Australia (11.8 million ha), Argentina (3.1 million ha) and China (2.3 million ha) (Yussefi and Willer, 2007). Table 3 shows detailed information of organic area in 2006 by country. There has been significant growth of organic areas in North America and Europe: Each continent has half million ha more over 2004. In most countries, organic farming is on the rise. In China, the organic land area has increased by 37.5% over that in 2001 (Shi-Ming and Sauerborn, 2006). In Liechtenstein, 26% of agricultural land area is managed organically, which is the highest percentage of organic area in the world (Table 4) (Yussefi, 2006).

Organic farming has been practiced in 120 countries of the world (FAO, 2002). It is reasonable to assume that uncertified organic farming is practiced in even more countries (Yussefi and Willer, 2007); about 50% of those are developing countries (Willer and Yussefi, 2000). However, the area of organic land is less than 1% of the total agricultural land of the world. The current organic area in each continent is presented in Figure 1 (Yussefi and Willer, 2007). The proportion of organically to conventionally managed land is highest in Europe. Latin America has the greatest total number of organic farms (Table 5) (Yussefi, 2006).

Table 3. Land area under organic management by country (Adapted from Yussefi, 2006; Yussefi and Willer, 2007).

#	Country	Organic land area (ha)
1	Australia	11,800,000
2	Argentina	3,000,000
3	China	2,300,000
4	Italy	954,361
5	USA	889,048
6	Brazil	887,637
7	Germany	767,891
8	Uruguay	759,000
9	Spain	733,182
10	UK	690,270
11	Chile	639,200
12	France	534,037
13	Canada	488,752
14	Bolivia	364,100
15	Austria	344,916
16	Mexico	295,046
17	Czech Republic	260,120
18	Peru	260,000
19	Greece	249,488
20	Ukraine	241,980
21	Sweden	206,579
22	Portugal	206,524
23	Sudan	200,000
24	Zambia	187,694
25	Kenya	182,438
26	Bangladesh	177,770
27	Finland	162,024
28	Tunisia	155,323
29	Denmark	154,921
30	Hungary	128,690
31	Uganda	122,000
32	Switzerland	121,387
33	India (provisional)	114,037
34	Turkey	108,597
35	Slovak Republic	93,943
36	Paraguay	91,414
37	Poland	82,730
38	Romania	75,000
39	Dominican Republic	72,425
40	Lithuania	64,545

Table 3. Continued

41	Nicaragua	59,000
42	Tanzania	55,867
43	Indonesia	52,882
44	Netherlands	48,152
45	Estonia	46,016
46	New Zealand	45,000
47	South Africa	45,000
48	Latvia	43,902
49	Norway	41,035
50	Kazakhstan	36,882
51	Colombia	33,000
52	Ireland	30,670
53	Russia	30,000
54	Japan	29,151
55	Korea, Republic of	28,218
56	Ecuador	27,436
57	Egypt	24,458
58	Belgium	23,728
59	Slovenia	23,032
60	Serbia/Montenegro	20,542
61	Pakistan	20,310
62	Azerbaijan	20,105
63	Morocco	20,040
64	Ghana	19,132
65	Venezuela	16,000
66	Sri Lanka	15,379
67	Guatemala	14,746
68	Philippines	14,134
69	Costa Rica	13,945
70	Thailand	13,900
71	Saudi Arabia	13,730
72	Syria	12,500
73	Bulgaria	12,284
74	Moldova	11,075
75	Cuba	10,445
76	El Salvador	9,100
77	Croatia	7,355
78	Cameroon	7,000
79	Vietnam	6,475
80	Israel	5,960
81	Panama	5,244
82	Iceland	4,910
83	Luxemburg	3,158
84	Senegal	2,500
85	Honduras	1,823
86	Belize	1,810

Table 3. Continued

87	Algeria	1,400
88	Jamaica	1,332
89	Taiwan	1,092
90	Lebanon	1,039
91	Cyprus	1,018
92	Nepal	1,000
93	Palestine	1,000
94	Zimbabwe	1,000
95	Liechtenstein	984
96	Albania	804
97	Malaysia	600
98	Mozambique	600
99	Armenia	598
100	Benin	400
101	Kyrgyzstan	400
102	Malawi	325
103	Bosnia Herzegovina	310
104	Fiji	200
105	Iran	200
106	Macedonia	192
107	Mali	170
108	Mauritius	150
109	Madagascar	129
110	Guyana	109
111	Togo	90
112	Trinidad & Tobago	80
113	Laos	60
114	Rwanda	50
115	Georgia	48
116	Burkina Faso	30
117	Jordan	30
118	Malta	13
119	Niger	12
Total Organic Area Covered by the FiBL Survey 2005/2006		31,502,786

Table 4. The ten countries with the highest percentage of organic area (Yussefi, 2006).

Countries	Percentage of land area under organic management (%)
Liechtstein	26.40
Austria	13.53
Switzerland	11.33
Finland	7.31
Sweden	6.80
Italy	6.22
Czech Rep.	6.09
Denmark	5.76
Portugal	5.42
Estonia	5.17

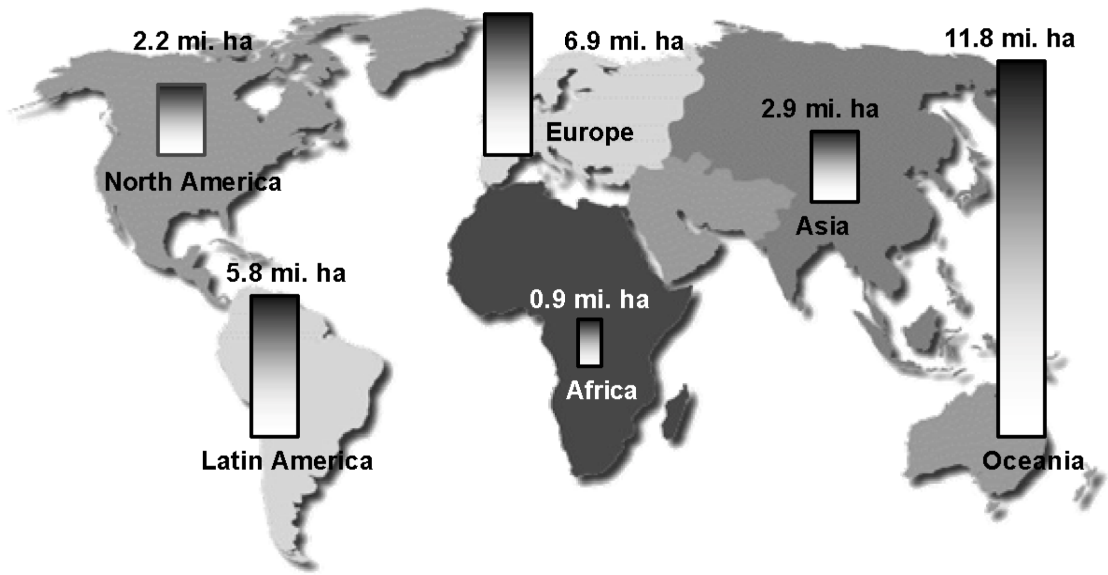

Figure 1. Areas under organic agriculture worldwide. (Adapted from Yussefi and Willer, 2007).

Table 5. Percentage of organic farms per continent (Yussefi, 2006).

Continent	Total of organic farms (%)
Latin America	31
Europe	27
Asia	21
Africa	18
North America	2.0
Oceania	1.0

In Europe, the share of organic land area is between 1.4 and 3.7%. In Africa, the area percentage under organic management is the lowest in the word (Yussefi and Willer, 2003; SOEL, 2003; FiBL, 2003). Latin America now is one of the regions with the highest growth rate of organic farming (Yussefi and Willer, 2003; FAO, 2002). This is perhaps because Latin America has a great deal of education and extension activities relating to ecological agriculture (Yussefi and Willer, 2003; FAO, 2002). Table 6 shows the main land use categories and crop categories under organic agriculture.

More than half of the organic agricultural land for which land use information was available (Table 6) is under permanent pastures/grassland. About one quarter is used for arable cropping (Willer et al., 2007).

Table 6. Global organic land by main land use categories (Willer et al., 2007).

Main category	Hectares
Permanent pastures/grassland	19,939,796
Arable land	4,156,754
Permanent crops	1,550,272
Other crops	1,393,595
Other	289,379
No information	3,228,387
Total	**30,558,183**

Organic agriculture by continent

Oceania

This area includes Australia and New Zealand as well as smaller countries like Fiji, Papua New Guinea, Tonga and Vanuatu. Altogether, more than 11.8 million ha and 2,689 farms are under organic management (Yussefi and Willer, 2007). Most of this area is pastoral land for low intensity grazing in Australia (Yussefi, 2006).

Growth in the organic industry in Australia has been strongly influenced by overseas demand. The key market for export of Australian organic products has changed over the years. In the early 2000s, it was Europe accounting for over 70% of Australian organic exports. Other countries such as Japan, the US, Singapore and Hong Kong were emerging as promising future export markets for Australian produce. Most organic beef was exported to the US.

In 2006, Australia agreed to adopt organic standards, which, once in place, can then be used by authorities to enforce on the domestic market. In New Zealand, a National Organic Standard was launched in 2003, underpinning the various certification schemes that already exist. Through the launch of the New Zealand Organic Sector Strategy, the government does acknowledge the importance of organic farming, but it only gives limited support (Yussefi and Willer, 2007).

North America

In North America, almost 2.2 million ha are managed organically, representing approximately a 0.6% share of the total agricultural area. Currently, the number of farms is about 12,000. North America has reached a growth rate of almost 30% in recent years (Yussefi and Willer, 2007).

The number of organic farmers is increasing at a rate of about 12% per year in the 1990s (USDA, 2000) and may have reached 20% annually between 2002 and 2007 (Willer and Yussefi, 2004). The US market has seen more and more organic products being introduced, the number of certification agencies accredited by USDA has grown, and talks are progressing to expedite international trade of organic products.

Since 1999, Canada has had a voluntary Canada Organic Standard that is not supported by regulations. The organic industry continues to devote its energies toward implementation of a mandatory national organic regulation to help expedite trade relations with such major trading partners as the US, the EU, and Japan (Yussefi and Willer, 2007).

Latin America

In Latin America, many countries have more than 100,000 ha of organic land, which are expanding fast. The total organically managed and certified area is now almost 6.4 million ha with an additional 6 million ha certified as forest and wild harvested areas (Yussefi, 2006).

The countries with the highest proportion of organic land are Uruguay, Mexico and Argentina. Argentina is the country with the largest organic land in the region, ranking second in the world, and a major part of their 3.1 million organic hectares are extensive grassland (Yussefi and Willer, 2007).

In general in the region, no governments provide direct subsidies or economic aid for organic production. The exception is Brazil, where the government recently issued an inter-ministerial Pro Organic Plan officially stimulating organic production, research, association building, marketing and trade (Yussefi, 2006). In Bolivia, an action plan for the ‘Promotion of the development of ecological production and establishment for a national control system’ was recently launched. Costa Rica and some others have official funding for research and teaching, Argentina and Chile have had official export agencies helping producers attend international fairs and print product catalogues, and in Mexico there is a growing interest from national and state agencies (Yussefi and Willer, 2007).

In Brazil, organic farming started in the 1970s. Its annual growth rate was around 10% in 1990s and is approximately 50% during the last three years, being higher than the EU and USA, where the growth rate is estimated at 20% and 30% per year, respectively (Darolt, 2006).

Central America has a young but fast growing organic agriculture. In fact, for the past five years total acreage under organic production has increased 15% annually (Table 7) (The organic standard, 2001). In Mexico, organic farming started in the late 1980s, and keeps growing fast in the past 5 years. Mexico has the highest number of organic farmers in Latin America, and almost all organic produces are destined for the US market (Darolt, 2001). Costa Rica is third in number of organic farmers after Mexico and Brazil (Darolt, 2001).

The major export organic crops are coffee, cacao, banana, sesame, pineapple and vegetables (González and Nigh, 2005). Organic coffee is of high demand worldwide, being produced in Mexico, Colombia, Brazil, Bolivia, Nicaragua, Guatemala and El Salvador (Darolt, 2001).

Table 7. Acreage under organic production in Central America (Adapted from the organic standard, 2001).

Country	Certified organic and in conversion land (ha)
Belize	1,810
Guatemala	14,746
El Salvador	4,900
Honduras	1,769
Nicaragua	7,000
Costa Rica	6,487
Panamá	5,111
Total in region	**41,823**

The area under organic management in Mexico has grown from 23,000 ha in 1996 to 216,000 ha in 2002 of which around 70% are in coffee (González and Nigh, 2005).

Europe

In the EU, organic farming has experienced a fast growth since the end of the 20th century (Lampkin, 2001). This is in part a result of the emphasis of the European Common Agricultural Policy (CAP) on environmentally sensitive agricultural systems and their policy implementation (Häring, 2003). There are almost 6.3 million ha under organic management with almost 160,000 organic farms. This constitutes 3.9% of the agricultural area (Yussefi and Willer, 2007).

In Austria and Switzerland, more than 10% of the agricultural area is managed organically (Mäder *et al.*, 2002; Soil association, 2000). However, the country with the highest number of farms and the largest organic area is Italy (Yussefi, 2006), where organic farming currently represents 7.94% of the total area farmed (IFOAM, 2003). For comparison, France has 1.8% of agricultural land under organic management (MAF, 2005). In Denmark, organic farming has been subsidized and covered 6.5% of the agricultural land in 2001 (Yussefi and Willer, 2003). The conversion from conventional to organic dairy farming occurred mainly in the mid 1990s (Petersen *et al.*, 2006), and further conversion in the next 8-10 years could reach 15% of the cultivated area (Christensen and Fradsen, 2001). The Dutch government intended to have 10% of the agricultural land under organic management by 2010 from the current 2.1%. (MAF, 2005; van Diepeningen *et al.*, 2006). In Ireland, farming is predominantly grass-based, so is the organic sector. A target of 3% of arable land under organic has been set for 2010 (Duggan, 2005). The area of organic and in-conversion land in the UK doubled between 1999 and 2000 (Rigby and Cáceres, 2001), with more than 500,000 ha of organic and in-conversion land, or

3% of the agricultural area of the country. Despite this expansion of the organic sector, the UK currently imports 75% of its organic food (Rigby *et al*., 2001).

Asia

In Asia, the area under organic management was rather small in the past. China, in 2004, had nearly three million ha, which were dedicated to organic pastures, but has not been certified (Yussefi, 2006). India reported 2.5 million ha under organic farming with 332 new certifications issued during 2004 (MAF, 2005)

Officially, the total organic area in Asia is almost 2.9 million ha, managed by 130,000 farms (Yussefi and Willer, 2007) with an addition of 6.4 million ha being certified as forest and wild harvested areas. China, India, and Russia are among the most significant countries producing organic products in Asia. Recently, aquaculture, particularly organic shrimp farming, has become popular, particularly in China, Indonesia, Thailand and Vietnam (Yussefi, 2006).

Africa

In Africa, organic production is rarely certified. Nevertheless, organic farming is increasing, especially in the southern countries. More than 1 million ha are now managed and certified organically. Additionally, 6.8 million ha are certified as forest and wild harvested areas (Yussefi, 2006).

An important growth factor in Africa is the demand for organic products by developed countries. Most certified organic production in Africa is geared towards export markets, mainly the EU (Yussefi and Willer, 2007). Another motivation is the maintenance and building of soil fertility on land threatened by degradation and erosion.

Impacts of organic farming

In many parts of the world, agriculture has caused environmental pressure, such as land degradation, water use and greenhouse gas emissions. Some specific impacts of agriculture on the global environment are documented below (Pimentel, 1994; Kendal and Pimentel, 1994).

- During the past 40 years almost one third of the world's cropland has been abandoned because erosion and degradation.
- Agriculture accounts for 80% of deforestation, and 40% of the world's population lives in regions where water resources are over drafted and stressed, and where users compete for water.
- Methane (CH_4) and nitrous oxide (N_2O) emissions from agriculture in the EU amounted to 383mi. tons of carbon dioxide (CO_2) equivalent in the year 2000, which correspond to approximately 10% of the total EU greenhouse gas emissions (Gugele *et al*., 2002).

The increase of environmental pressure from agriculture is unlikely to reverse in the near future, since the world population continues to increase faster than global food supply, and diets continue to shift towards animal products (Goodland, 1997; Pimentel, 1994; Kendal and Pimentel, 1994).

A transition to organic farming could be a viable way of reducing energy use and greenhouse gas emissions. Synthetic chemicals and fertilizers are significant sources of energy use, and the transition to organic agriculture, being less reliant on these inputs, would alleviate these impacts (Wood *et al*., 2006).

According to FAO (1998), organic farming would have long lasting, mostly beneficial effects on such important areas as:

*** Long-term productivity** *of the land*: Protecting soils and enhancing their fertility would ensure productive capacity for future generations. Farmers often quote deteriorating soil quality as a major reason for adopting organic management. It can, therefore, be assumed that those farmers who adopted organic management practices found ways to improve the quality of their soil within the new management system, or at least stemmed the deterioration. Security of land tenure is important to the success of this task. If security is not guaranteed, there is little incentive for farmers to invest in a method that might only bring them income in the future rather than immediate rewards.

*** Food security and stability:** In organic agriculture, a diversity of crops is often grown and many kinds of livestock kept. This diversification minimizes the risk of variation in production, as different crops react differently to climatic and edaphic variations, or have different times of growth (both in the time of the year and in length of the growth period). Consumers' demand for organic food and premium prices provide new export opportunities for farmers of the developing world, thus increasing their self-reliance. Organic agriculture can contribute to local food security in several ways. Organic farmers do not incur high initial expenses so less money is borrowed. Synthetic inputs, unaffordable to an increasing number of resource-poor farmers due to decreased subsidies and the need for foreign currency, are not used. Organic soil improvement may be the only economically sound system for resource-poor, small-scale farmers.

*** Environmental impact:** In a study with pesticides and fruit thinners used in apple production, Reganold *et al*. (2001) showed that the total environmental impact rating of the conventional system was 6.2 times that of the organic one. Organic farmers forego the use of synthetic fertilizers. Most certification programs also restrict the use of mineral fertilizers, which can only be used to the extent necessary to supplement organic matter produced on the farm. There are environmental advantages to this: non-renewable fossil energy needs and N leaching is often reduced (Eltun, 1995). Instead, farmers enhance soil fertility through use of manure (although the kind and its handling have significant effects on N content, and poor usage can create leaching problems), crop residues (e.g. corn stover, rice straw), legumes and green manures, and other natural fertilizers (e.g., rock phosphate, seaweed, guano, wood ash). Within the agricultural sector, dairy production systems represent the largest source of CH_4 and N_2O emissions and may therefore have a large potential for greenhouse gas mitigation (Weiske *et al*., 2006). Lal *et al*. (1998) point out that SOM can significantly mitigate the greenhouse effect (e.g., via carbon sequestration). Disadvantages for not using synthetic chemicals must be considered as well: energy needs may escalate if thermal and mechanical weeding or intensive soil tillage is used. Many resource-poor farmers do not have access to livestock manure, often an important fertility component. Sometimes immature composts are used, which may contain pathogens and other contaminants. Finally, some areas in tropical countries may have such low soil fertility that synthetic inputs are essential. Soil protection techniques used in organic agriculture (e.g., terracing in the humid tropics, cover crops) combat soil erosion, compaction, salinization, and degradation of soils, especially through the use of crop rotations and organic materials that improve soil fertility and structure (including beneficial microbial influence and soil particle aggregation). Integrating trees and shrubs into the farming system also conserves soil and water and provides a defense against unfavorable weather conditions such as winds, droughts, and floods. Techniques used in organic agriculture also reduce water pollution and help conserve water on the farm.

Although the benefits (both real and perceived) of organic farming and organic food are many, potential negative effects should also be noted, including the risk of contamination for human consumption (Pretty,1995; Rigby and Cáceres, 2001). For example, nitrate leaching may contaminate ground water used for drinking, or organic livestock might be contaminated with disease-causing microorganisms from manure and by animal parasites (Rosati and Aumaitre, 2004).

*** Social impact:** The social impact of organic farming is considerable as mentioned in the IFOAM's Principal Aims. The main benefit according by some organic farmers in developing countries (e.g., China and India) is that they now have better standards of living. Good product prices, low unemployment, dropped rural emigration, and reduced health risks (from chemicals) are the results of farming organic (MAF, 2005).

In summary, the organic food movement apparently had its roots in a philosophy of life, beginning perhaps with Rudolf Steiner, a notable German thinker, in the 1920s. One of its common believes is that natural products are good, whereas man-made chemicals are not, or at least not as good as natural ones. This partially explains why organic farming avoids the use of synthetic fertilizers and pesticides. Certainly, organic farming has many benefits ranging from reduced environmental pollution to increased soil quality. Let us hope that organic farming will lead all farmers, and their consumers, toward a more productive, prosperous, sustainable, and healthy future.

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