Organic Farming: Reality and Concerns

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ABSTRACT

Organic farming is being proposed as a measure to restore sustainability of agriculture production, with an eye on maintaining environmental amenity at the same time. Although it has made remarkable progress in recent times, the scientific community stands rather skeptical about the ability of organic agriculture to produce enough food to feed the fast-growing population throughout the world. Despite being recognized to offer some health and environmental benefits, its low-yield potential with respect to conventional farming, and inadequate availability of organic inputs to meet the crop nutrient requirements are some constraints that put in jeopardy its future prospect as a universally acceptable alternative agriculture system. In view of these contrasting opinions, the present review attempts to explore the extent, distribution, merits and limitations of the organic agriculture. Possible impact of organic farming on soil health and India's food security is also discussed.

Keywords: Organic agriculture, food security, soil health, sustainable agriculture, environment

INTRODUCTION

Organic farming is arguably one of the most intensively contested topics in recent times. It is being proposed as an alternative way of farming to achieve the sustainability in agricultural production. The roots of modern organic farming can be traced in Europe back to the first quarter of the early 20th century (Stockdale et al. 2001). In 1924, the Austrian philosopher Dr. Rudolf Steiner conceptualized and advocated organic agriculture, and in 1927, a trademark 'Demeter' was introduced for organic products. Organic movement in India owes its origin primarily to the work of Sir Albert Howard, who believed that a shift from nature's methods of crop production to adoption of newer methods leads to the loss of soil fertility (Howard 1940). Although he was born and educated in England, his most important work occurred in India where he served as Imperial Economic Botanist to the Indian Government from 1905 to 1924 and as Director of the Institute of Plant Industry, Indore from 1924 to 1931. Although organic farming is prehistoric in the widest sense, Sir Albert Howard is widely considered to be the *"father of organic farming"* in the sense that he was a key founder of the post-industrial-revolution organic movement.

There is no singular definition for organic farming as the term refers to a movement rather than to a single policy. Organic agriculture avoids or largely excludes the synthetic fertilizers, pesticides; growth regulators and livestock feed additives, and to this list may be added the use of genetically modified (GM) crops. Organic farming system solely depends on the use of crop residues, animal manures, green manures, off-farm organic wastes, crop rotation incorporating legumes and biological pest control to maintain soil productivity (Palaniappan and Annadurai 1999). The philosophy is to feed the soil rather than the crops to maintain soil health, and it is a means of giving back to the nature what has been taken from it (Funtilana 1990). In contrast to organic farming, the conventional farming relies more on fertilizing the crops and

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treating them with different agrochemicals for removing the productivity constrains.

A large number of terms are used as alternatives to organic farming. These are: biological agriculture, ecological agriculture, bio-dynamic, organic-biological agriculture and natural agriculture. According to the National Organic Standards Board of the US Department of Agriculture (USDA), the word 'Organic' has the following official definition (Lieberhardt 2003): "An ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on the minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony." According to Codex Alimenarius (FAO 2001), organic agriculture is a holistic production management system which promotes and enhances health, including biodiversity, biological cycles and soil biological activity. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people (Scialabba and Hattam 2002).

RELEVANCE OF ORGANIC FARMING

The relevance and need for an eco-friendly alternative farming system arose from the ill effects of the chemical farming practices adopted worldwide during the second half of the last century. The methods of farming evolved and adopted by our forefathers for centuries were less injurious to the environment. People began to think of various alternative farming systems based on the protection of environment, which in turn would increase the welfare of the humankind by various ways like clean and healthy foods, an ecology which is conducive to the survival of all the living and non-living things, low use of the non-renewable energy sources, etc. Many systems of farming came out of the efforts of many experts and laymen. However, organic farming is considered to be the best among them because of its scientific approach and wider acceptance all over the world.

There are three categories of opinions about the relevance of organic farming for India. The first one simply dismisses it as a fad or craze. The second category, which includes many farmers and scientists, opines that there are merits in organic farming, but we should proceed cautiously considering the national needs and conditions in which Indian agriculture functions. They are fully aware of the environmental problems created by the conventional farming. But many of them believe that yields are lower in organic cultivation during the initial period and also the cost of labour tends to increase therein. The third one is all for organic farming and advocates its adoption wholeheartedly. They think that tomorrow's ecology is more important than today's conventional farm benefits (Narayanan, 2005).

CURRENT STATUS OF ORGANIC AGRICULTURE

International

Organic agriculture is developing rapidly, and statistical information is now available from 160 countries of the world. Its share of agricultural land and farms continues to grow in many countries. The main result of the global survey on certified organic farming is presented in Table 1 (IFOAM Survey 2012).

Asia

The total organic area in Asia is nearly 2.9 million hectares. This constitutes nine percent of the world's organic agricultural land, and involves 230,000 producers. The leading countries are China (1.6 million hectares) and India (1.0 million hectares). The highest shares of organic land of all agricultural lands are in Timor Leste (7%). Organic wild collection areas play a major role in India and China. Production of final processed products is growing, although a majority of productions is still fresh produce and field crops with low value-added processing, such as dry or processed raw ingredients. Aquaculture (shrimp and fish) on the other hand, is emerging in China, Indonesia, Vietnam, Thailand, Malaysia and Myanmar. Textile is another important area. Sector growth is now also driven by imports, and local markets have taken off in many of the big cities in the South and Eastern part of the region besides Japan, South Korea, Taiwan and Singapore. Kuala Lumpur, Manila, Bangkok, Beijing, Shanghai, Jakarta, Delhi, Bangalore and other cities are increasing internal consumption of organic products. Nine organic

Table 1: Organic Agriculture 2012: Key Indicators and Leading Countries

Indicator	World	Leading countries
Countries with data on certified organic agriculture	2010: 160 countries	
Organic agricultural land	2010: 37 million hectares (Mha) (2009: 37. Mha; 1999: 11 Mha)	Australia (12 Mha, 2009) Argentina (4.2 Mha) US (1. Mha, 2008)
Organic agricultural land	2010: 0.9 %	Falkland Islands (Malvinas) (35.9 %) Liechtenstein (27.3 %), Austria (19.7 %)
Growth of organic agricultural land	2010: -50'000 ha = -0.1% (2009: +1.9 Mha = +5%; 2008: +2.9 Mha = +9%)	France: +168,000 ha (+24 %) Poland: +155,000 ha (+42 %) Spain: +126,000 ha (+9%)
Further, nonagricultural Organic areas (mainly wild collection)	2010: 43 Mha (2009: 41 Mha; 2008: 31.9 Mha)	Finland (7.8 Mha) Brazil (6.2 Mha; 2007) Cameroon (6 Mha)
Producers	1.6 million producers (2009: 1.8 million producers; 2008: 1.4 million producers)	India (400,551), Uganda (188'625), Mexico (128,826)
Organic market size	44.5 billion euros or 59.1 billion USD (2009: 54.1 billion USD 1999: 15.2 billion USD) Source: Organic Monitor	US (20.2 billion euros or 26.7 billion USD, Germany (6 billion euros or 8.4 billion USD), France (3.4 billion euros or 4.7 billion USD)
Per capita consumption	2010: 6.5 euros or 8.6 USD	Switzerland (153 euros or 213 USD), Denmark (142 euros or 198 USD) Luxemburg (127 euros or 177 USD)
Number of countries with organic regulations in 2010	84 countries (2009: 74 countries)	
Organic certifiers in 2010	2011: 549 certifiers(2010: 532; 2009 489)	Japan, USA, South Korea
Number of IFOAM affiliates	1.1.2012: 870 affiliates from 120 Countries (2011: 757 from 115 countries; 2000: 606)	Germany: 105 affiliates; India: 50 affiliates; China: 41 affiliates; South Korea: 39 affiliates; United States: 39 affiliates

Source: FiBL and IFOAM; for total global market: Organic Monitor; for number of certifiers: Organic Standard/Grolink.

regulations are in place. In seven countries, work on national standards and regulations is in progress.

India

Organic farming has received considerable attention in India, and Ministry of Agriculture and Cooperation, Govt. of India constituted a Task Force on Organic Farming under the chairmanship of Dr. Kunwarji Bhai Yadav, ex-Director of Agriculture, Gujarat, in the year 2000. The Committee in its report emphasized on the need for consolidating the information on organic farming and its benefits. One of the steering committees constituted by this Task Force under the Chairmanship of Dr. M.S. Swaminathan, Chairman, a Farmers' Commission has suggested taking up organic farming as a challenging national task and to take up this as a thrust area of the 10th Five-Year Plan. The steering committee advocated giving a boost to organic farming in the rainfed areas and in the north-eastern states where there is limited use of agricultural chemicals. Madhya Pradesh took early lead in this regard and Uttaranchal, and Sikkim followed the suit and these states have declared themselves as organic states (Marwaha and Jat 2004). The Ministry of Commerce launched the National Organic Programme in April 2000, and Agricultural and Processed Food Products Exports (APEDA) is implementing the National Programme of Organic Production (NPOP) (Gouri, 2004). Under the NPOP, documents like National Standards, accreditation criteria for accrediting inspection and certification agencies, have been prepared and approved by the National Steering Committee. An Indian Organic Logo was released in July, 2002. Agriculture and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce, GOI is the key Accreditation agency, the others being Coffee Board, Spice Board, Tea

Board, Coconut Development Board and Directorate of Cocoa and cashew Board. The list of accredited inspection and certification agencies in India is given in Table 2.

Recent survey (FiBL and IFOAM 2012: The World of Organic Agriculture 2011 and 2012 *www.organic-world.net*) showed that there was around 1 Mha of land for certified organic food production at the farm level and 3.6 Mha of certified forest area for collection of wild herbs in India during 2010, but the actual area under organics is much more. In Maharashtra alone about 0.5 million ha area is under organic farming since 2003; out of this, only 10,000 ha is the certified area. In Nagaland, 3,000 ha is under organic farming with crops like maize, soybean, ginger, large cardamom, passion fruit and chilli. The state of Rajasthan has 5,631 ha under organic farming with crops like pearlmillet, wheat, mungbean, guar, mustard and cotton (Bhattacharya and Chakraborty 2005).

There is a tremendous potential to increase India's share in international trade on organic food by including commodities such as durum wheat, aromatic rice (*e.g.* Basmati rice, Keteki Joha), fruits, aromatic/medicinal herbs, vegetables, coffee, pulses, sugar, etc. India has competitive advantages in the world markets due to low production costs and availability of diverse climates to grow a large number of crops round the year.

Table 2: Accredited inspection and certifying agency in India

Sl. No.	Agency	Address
1	Association for Promotion of Organic Farming	UAS Alumni Association Building, Bellary Road, Hebbal Bangalore-560024 *Email: apof@vsnl.net; apofindia@hotmail.com*
2	Bioinspecta	Ackerstrasse, Postfach CH-5070 Frick, Switzerland Branch office in India: Bioinspecta C/O Indocert Thottumugham PO Aluva-683105, Cochin, Kerela, India *Email: admin@bio-inspecta.ch*
3	Ecocert International (Germany)	Ecocert South Asia Branch Office, 54 A, Kanchan Nagar, Nakshetrawadi , Aurangabad-413002 Maharastra State *Email: ecocert@sancharnet.in*
4	Indian Organic Certification Agency (INDOCERT)	Thottumugham PO Aluva-683105, Cochin, Kerela, India *Email: admin@bio-inspecta.ch*
5	Indian Society for Certification of Organic Products (ISCOP)	Rasi Building, 162/163, Ponnaiyarajapuram, Coimbatore-641 001, Tamil Nadu *Email: profdrkkk@yahoo.com*
6	International Resources for Fairer Trade	Sona Udyog (Industrial Estate), Unit 7, Parsi Panchayat Road, Andheri (E), Mumbai-400 069 *Email: arun@irft.org*
7	IMO Control Private Limited	26, 17th Main HAL 2nd 'A' Stage , Bangalore-560008 *Email: imoind@vsnl.com*
8	LACON GMBH, Germany	Branch office in India: LACON, C/O Renewable Energy Centre, Mithradham Chunangaveli, Alwaye-683 105, Kerela *Email: laconindia@indiatimes.com*
9	Naturland-Association for Organic Agriculture	M-13/27, DLF City II, Gurgaon-122002 (Haryana) *Email: nidia@naturland.de, prabhamahale@vsnl.com*
10	SGS India Pvt. Ltd	Business Manager, M/S SGS India Pvt. Ltd. 250 Udyog Vihar, Phase –IV, Gurgaon-122015 *Email: sudarshan_sharma@sgs.com*
11	Skal International (Netherlands)	Skal International and Certification Agency No. 191. 1st Main Road, Mahalaxmi Layout, Bangalore-560086 *Email: naraupa@blr.vsnl.net.in, skalindia@vsnl.com*
12	National Organic Certification Association (NOCA)	Pune

ORGANIC STANDARDS

Globally, there are about 60 standards for organic foods. Important features of five of these are given in Table 3.

Under NPOP programme, the Government of India has developed 'National Standards for Organic Export. The Ministry of Agriculture, GOI has in principle, accepted these standards for the domestic purpose also. The scopes of these standards are:

(i) Lay down policies for development and certification of organic products.
(ii) Facilitate certification of organic products conforming to the National Programme containing the standards for organic production.
(iii) Institute a logo and prescribe its award by accredited bodies on products qualifying for bearing organic label. A National Steering Committee (NSC) comprising Ministry of Commerce, Ministry of Agriculture, APEDA, Spice Board, Coffee Board, Tea Board and various other Government and private organizations associated with the organic movement in monitoring the overall activities under NPOP has been constituted. NPOP standard has already got equivalency with standard of EU Commission.

ISSUES OF CONCERN

Despite the perceived importance of organic farming in contemporary agriculture, there are quite a few concerns, which persist and apparently hinder the growth and proliferation of this system of farming. Some major concerns are interrogated hereunder:

Are organically produced foods more nutritious and tastier than their conventionally- grown counterparts?

There appears no conclusive scientific evidence to support the claims that organically produced food is of better quality and taste, and that use of chemical fertilizers deteriorates it. Since plants absorb nutrients, mostly in inorganic forms irrespective of the source of applied nutrients, these claims need to be substantiated by authentic data from well-established long-term experiments. Exhaustive review made by Woese (1997) and Heaton (2001) indicated that in 43% cases, organic food was having higher nutrients, in 45% cases equal and in 11% cases lower nutrients compared to conventionally grown foods. On the contrary, nitrate levels were lower in 70% of organic products compared to the conventionally grown counterparts. Results from a four-year study (reported in 2012) conducted by scientists from Standford University say that organic produce does not get any extra points for nutrition and taste. The conventionally grown fruits and vegetables did have more pesticides residues, but the levels were almost always under the allowed safety limits (*http://www.nytimes.com/2012/09/04/science/earth/study-questions-advantages-of-organic-meat -and-produce.html*). In many instances in India, it was found that pesticide residues in conventionally grown foods were more than the safer limits. Under

Table 3: Some characteristics of international standards

IFOAM	• Established in 1972 • Headquarter in Germany • Umbrella organization for Organic Agriculture Association • Developed international basic standards of organic agriculture • Established IFOAM accreditation programme (1992) to accredit certifying bodies • Set up International Organic Accreditation Service (IOAS) in July 2001
CODEX	• Codex Alimentarious Commission – a joint FAO/WHO intergovernmental body • Established in 1962 • Produced a set of guidelines for organic production
EU regulation	• Laid out a basic regulation for European Union's organic standards in Council regulation NO 2092/91 (June 1991) • Regulations give guidelines for the production of organic crops in the European Community
Demeter	• Demeter International is a world wide network of 19 international certification bodies in Africa, Australia, Europe • Developed guidelines for biodynamic preparation
JAS	• A set of guidelines 'Japan Agricultural Standards' for organic production

this circumstance, organically grown foods could be safer than the conventionally grown foods.

Does organic farming sustain higher yield?

Numerous individual studies have compared the yields of organic and conventional farms, but few have attempted to synthesize the information on a global scale. A first study of its kind Badgley et al. (2007) concluded that organic agriculture matched, or even exceeded, conventional yields, and could provide sufficient food on current agricultural land. However, this study was contested by a number of authors; the criticism included their use of data from crops not truly under organic management, and inappropriate yield comparisons (Cassman 2007; Connor 2008). A paper published recently in *Nature* by Seufert et al. (2012) shows that organic yields are typically lower than the conventional yield. They use a comprehensive meta-analysis to examine the relative yield performance of organic and conventional farming systems globally. The yield differences are highly contextual depending on system and site characteristics and range from 5% lower organic yields (rain-fed legumes and perennials on weak acidic to weakly-alkaline soils), 13% lower yields (when best organic practices are used) to 34% lower yields (when conventional and organic systems are most comparable). Under certain conditions with good management practices, particularly crop types and growing conditions, organic systems can nearly match conventional yields, whereas under others, it at present cannot. In India, long-term studies from around the country indicate that sustained yield and soil productivity can be achieved with balanced nutrient addition using animal manures and/or commercial fertilizers. To establish organic agriculture as an important tool in sustainable food production, the factors limiting organic yields need to be more fully understood, alongside assessment of the many social, environmental and economic benefits of organic farming systems (Seufert et al. 2012).

Is organic farming eco-friendly?

Recent studies have highlighted the substantial contribution of organic agriculture to climate-change mitigation and adaptation (Niggli et al. 2009; Scialabba and Muller-Lindenlauf 2010). The potential of organic agriculture to mitigate climate change is mostly claimed based on assumptions about the soil carbon sequestration potential of organic management. Organic agriculture has various positive environmental effects, chiefly enhancing biodiversity (McNeely and Scherr 2001; Hole et al. 2005) and reducing the energy use for agricultural production (Ziesemer 2007). Emissions of green house gases (GHG) from mineral fertilizer production, which contribute 1% to the global anthropogenic greenhouse-gas emissions, are totally omitted (FAOSTAT; EFMA; Williams et al. 2006).

There is scientific evidence that organic agriculture can sequester more carbon than conventional agricultural practices or inhibit the carbon release. All available studies showed higher carbon stocks in organic systems as compared to conventional systems. Niggli et al. (2009) estimated the global average sequestration potential of organic croplands to be 0.9-2.4 Gt CO_2 per annum, which is equivalent to an average sequestration potential of about 200 to 400 kg C/ha/yr for all croplands. Most of these published literatures originated from the developed world under temperate climate. Published literature from tropical world and developing countries are limited. There is apprehension that under tropical climate, organic farming may not adequately contribute to the carbon sequestration in soil. Numbers of studies have indicated that 70-80% of the added carbon in soil under tropical conditions escapes to the atmosphere as CO_2. Would the addition of larger quantities of organic residues in organic farming promote global warming? This may be an important area of research, particularly in tropical countries.

Organic agriculture has been promoted as a partial means for mitigating agricultural CH_4 and N_2O emissions. Co-benefits claimed lately for organic agriculture are reduced nitrogen losses to the environment and, more importantly, enhanced soil carbon sequestration, which together may offset between 60 and 92% of contemporary agricultural greenhouse-gas emissions if all land were converted to organic practices (Scialabba and Müller-Lindenlauf, 2010; Niggli et al. 2009). In contrast, a recent study (Qin et al. 2010) in Southeast, China reveals that relative to conventional rice paddies, organic cropping systems increased seasonal CH_4 emissions from 20-35% under various water regimes. NO_2-N emission from organic paddy was reported to be significantly higher than its conventional counterparts. The net global warming potentials of CH_4 and N_2O

emissions from organic rice paddies relative to conventional rice paddies were significantly higher or comparable under various water regimes. The greenhouse-gas intensities were greater, while carbon efficiency ratios were lower in organic relative to conventional rice paddies. The results of this study suggest that organic cropping system might not be an effective option for mitigating the combined climatic impacts from CH_4 and N_2O in paddy rice production.

Does organic farming improve soil fertility?

Long Term Fertilizer Experiments (LTFEs) conducted under varying agro-climatic and soil conditions have shown that balanced application of chemical fertilizers over a period of three decades sustained crop productivity. A paper published in *Nature* by Trewaves (2001) points out the likely hazards of relying solely on organic sources of nutrients. Long-term application of balanced chemical fertilizers is known to increase organic carbon owing to higher root biomass production. Long-term studies from around the country indicate that sustained soil productivity can be achieved with balanced nutrient addition using animal manures and/or commercial fertilizers.

ORGANIC FARMING AND INDIA'S FOOD SECURITY

Agriculture in India is one of the most important sectors of its economy. It provides livelihood to almost two-thirds of the work force in the country and contributes substantially to India's GDP. About 43 % of India's geographical area is used for agricultural activity. Agriculture is the single largest employment provider and plays a vital role in the overall socio-economic development of India. A large number of production systems are in practice in different parts of the country. Large-scale use of inputs both organic and inorganic has been a common sight in many of the farming situations in the past several decades. However, in recent times the concept of organic farming is being forcefully projected as the method for sustaining the agricultural production in the country.

At present, there is a gap of nearly 10 million tonnes between annual addition and removal of nutrients by crops, which are met by mining nutrients from soil. A negative balance of about 8 million tonnes of NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. Even the most optimistic estimate at present shows that only 25-30 per cent nutrient needs of Indian agriculture can be met by utilizing various organic sources. With ever increasing population, having huge requirement of food and meager availability of organic resources, pure organic farming does not appear feasible in India. The commercial mineral fertilizers will have to bear the main burden of supplying plant nutrients to meet the food requirement of increasing population. The gap between nutrient addition and removal causing the nutrients mining from soils cannot be allowed to continue in order to avoid the dire consequences in days to come. Therefore, organic resources should be used in conjunction with commercial fertilizers to narrow down the gap between addition and removal of nutrients by crops as well as to sustain the quality of soil and achieve higher productivity.

Before jumping into the organic farming bandwagon, we need to have answers to the following questions: "What level of crop yield/ productivity is acceptable? Is it suitable for a country like India with a large population to feed? Whether available organic sources of plant nutrients are sufficient for pure organic farming? And, are organic farming technologies sustainable in the long run?" Whether organic farming can address the multitude of problems faced by Indian agriculture at present is a major issue. Further, the virtues attributed to organic farming need to be rechecked before coming to any conclusions.

ORGANIC FARMING AND SOIL HEALTH

Soil is a key element in increasing crop yields. Maintaining its quality is therefore, important for the sustainable management of agricultural lands. The use of animal manure has been shown to be influential in enriching soil carbon content. However, few long-term studies of soil quality have been performed on organically cultivated lands. Promoting soil health and encouraging the development of soil organic matter has always been central tenets of the organic approach, and the contribution of organic systems to this area has been of considerable interest.

The potential for agricultural systems to sequester atmospheric carbon dioxide (CO_2) through building levels of soil carbon has been an area of considerable interest in recent years, in view of greenhouse-gas reduction targets set by the Kyoto Protocol and the Climate-Change Act (2008). Numbers of studies have shown positive effects on levels of organic carbon in soils as well as improvement in soil health under organic farming practices (Clement and Williams 1967; Grace et al. 1995, cited by Watson et al. 2002; Hepperly et al. 2006). However, the exact quantification of benefits in terms of the amount of soil organic carbon (SOC) accumulation, compared to conventional, is still an area of debate. What is clear from existing studies is that the diversity in the approaches used to carry out assessments make comparisons difficult.

A few comparative studies have been conducted to look at soil quality under conventional and organic agricultural systems. At the Rodale Institute in Pennsylvania, organically managed soil had greater soil organic carbon and total nitrogen, and lower nitrate leaching loss than conventionally managed soil (Drinkwater et al. 1998), as well as greater biological soil quality (Yakovchenko et al. 1996).

At the end of 4 years of management of an apple orchard in Washington, soil bulk density, water-filled pore space, and nitrate-N were lower under organic than conventional management, while soil microbial biomass carbon was greater under organic than conventional management (Glover et al. 2000). All other soil properties (viz. aggregate stability, total nitrogen, extractable phosphorus, cation exchange capacity, pH, electrical conductivity, microbial biomass nitrogen, organic carbon and earthworm population) were not different between conventional and organic management.

At the end of 40-47 years of dairy farm management in Denmark, organically managed soil had greater fragment size, aggregate stability in water, and microbial biomass carbon than conventionally managed soil (Schjønning et al. 2002). Several other physical and biological properties were not different between management systems, but ergosterol, an indicator of soil fungi, was lower in abundance under organic than conventional management systems for some unknown reason.

At the end of 21 years of crop rotation management in Switzerland, soil organic carbon and total nitrogen were greater under biodynamic management than conventional management, but organic management and integrated management (combination of manures, inorganic fertilizers, and herbicides) were intermediate (Flieâbach et al. 2007). Soil microbial biomass carbon and dehydrogenase activity were greater under organic than under conventional management, but basal soil respiration was not different between the two systems.

Between 5 paired farms in North Dakota and Nebraska, total and microbial carbon and nitrogen, and mineralizable carbon and nitrogen were greater under organic than under conventional management (Liebig and Doran 1999). The authors stated that the capacity of organic production practices to improve soil quality was mainly due to use of more diverse crop sequences, application of organic amendments, and less frequent tillage.

The aforementioned comparative studies had consistently greater soil microbial biomass carbon under organic than under conventional management. Depending upon the suite of soil properties measured, various other soil microbial activity assays (dehydrogenase activity, mineralizable carbon, and mineralizable nitrogen) were also greater under organic than conventional management. Total organic carbon and nitrogen were sometimes greater under organic management, but not always. Various soil physical properties were often greater under organic than under conventional management, but this effect was not consistent. From the relatively few studies available, it can be concluded that total and biologically active fractions of soil organic matter would be important response variables characteristic of organic management systems. In addition, there is a great need to quantitatively assess the difference between conventional and organic agricultural systems across a wide range of ecological conditions using a consistent suite of soil biological, physical, and chemical indicators. Inherent conditions within a particular eco-region may be strikingly different, resulting in significant variation in how soil responds to organic management.

Under Indian conditions, long-term studies to prove conclusively the superiority of organic farming over conventional farming in improving soil health are not available. Therefore, setting up of experiments to prove the relative advantage of organic farming over conventional one under the prevailing soil and climatic conditions is urgently needed.

CONCLUSION

There are many factors to consider in balancing the benefits of organic and conventional agriculture, and there are no simple ways to determine a clear 'winner' for all possible farming situations. However, instead of continuing the ideologically charged 'organic versus conventional' debate, we should systematically evaluate the costs and benefits of different management options. In the end, to achieve sustainable food security we will probably need different alternatives including organic, conventional, and possible 'hybrid' systems to produce more food at affordable prices, ensure livelihoods for farmers, and reduce the environmental costs of agriculture.

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