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Organic agriculture: Way towards sustainable development

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ABSTRACT

Organic agriculture has a potential to fulfill the food requirement of the world with sustainable resource utilization. This review illustrates how organic agriculture plays a role towards sustainable utilization of resources in food production as well as development with less pollution and contribution to the green house gases; ultimately climate change. Recent research in the field concluded that organic farming is better equipped to feed us now and well into the ever changing future. As Organic yields match conventional yields, Organic outperforms conventional in years of drought, Organic farming uses 45% less energy and is more efficient, Conventional systems produce 40% more greenhouse gases, Organic farming systems are more profitable than conventional and most important organic farming systems build rather than deplete soil organic matter which supports the soil micro, meso and macro fauna and makes the soil a living body; making it a more sustainable system. Organic agriculture offers a unique combination of environmentally-sound practices with low external inputs while contributing to food availability. To avoid ill effects of the conventional farming system it's an urgent need to adopt the organic farming practices, it not only improves the health of human community by providing safe food but also has the potential to mitigate climate change mostly claimed on the basis of assumptions concerning the soil carbon sequestration potential of organic management. Organic agriculture is the way towards sustainable development of mankind.

Keywords: Organic Agriculture, Sustainable development, conventional agriculture, food security, pollution mitigating potential.

1. Introduction

Agriculture sector is vital for the food and nutritional security of the nation. The sector remains the principal source of livelihood for more than 58% of the population though its contribution (14.2%) to the national GDP (Department of Agriculture and Cooperation, 2011). Compared to other countries, India faces a greater challenge, since with only 2.3% share in world's total land area; it has to ensure food security of its population which is about 17.5% of world population. This leads to excessive pressure on land and fragmentation of land holdings. On the other side the annual consumption of fertilizers in nutrient terms (N, P & K), has increased from 0.7 lakh MT in 1951-52 to 264.86 lakh MT 2009-10, while per hectare consumption of fertilizers, which was less than 1 Kg in 1951-52 has risen to the level of 135.27 Kg (estimated) in 2009-10 (Department Of Fertilizers, 2011). Intensive use of inorganic fertilizers and pesticides has been an important tool in the drive for increased crop production. In fact more fertilizers consumption is a good indication of agricultural productivity but depletion of soil fertility is commonly observed in soils. This continuous and massive application of the agrochemicals causing degradation of environment in terms of reduction in soil fertility, water pollution and indirectly significant contribution to the global warming, climate change and ozone layer depletion. According to the National Bureau of Soil Survey and Land Use Planning (NBSSLUP) 21.97 million hectare (mha) of land is degraded in terms of acidity and alkalinity /salinity (Bhattacharyya et al., 2005). Thus, the indiscriminate use of the fertilizer directly affects the soil health in terms of productivity and mineral composition.

Greenhouse gas (GHG) emissions from the agricultural sector account for 10–12% or 5.1–6.1 Gt of the total anthropogenic annual emissions of CO2-equivalents (IPCC, 2007). However, this accounting includes only direct agricultural emissions; emissions due to the production of agricultural inputs such as nitrogen fertilizers, synthetic pesticides and fossil fuels used for agricultural machinery and irrigation are not calculated. Furthermore, land changes in carbon stocks caused by some agricultural practices are not taken into account, e.g., clearing of primary forests. Emissions by deforestation due to land conversion to agriculture, which account for an additional 12% (Metz et al., 2007) of the global GHG emissions, can be additionally allocated to agriculture. Thus, agriculture production practices emit at least one-quarter of global anthropogenic GHG emissions and, if food handling and processing activities were to be accounted for, the total share of emissions from the agriculture and food sector would be at least one-third of total emissions. Considering the high contribution of agriculture to anthropogenic GHG emissions, the choice of food production practices can be a problem or a solution in addressing global warming. Recent studies have highlighted the substantial contribution of organic agriculture to climate change mitigation and adaptation (Niggli et al., 2009). The potential of organic agriculture to mitigate climate change is mostly claimed on the basis of assumptions concerning the soil carbon sequestration potential of organic management (Scialabba and Lindenlauf, 2010).

Organic agriculture offers a unique combination of environmentally-sound practices with low external inputs while contributing to food availability (Zundel and Kilcher, 2007). The objective is to describe the potential of the organic agriculture to provide an alternative way for conventional agricultural practices which leads to a sustainable resource utilization and contributes in mitigating global problems like climate change.

2. Concept of organic agriculture

A large number of terms are used as an alternative 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: *“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.”* (Lieberhardt, 2003)

According to the Codex Alimentarius Commission (FAO, 2001), “*organic agriculture is a holistic production management system that avoids use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people”*. To meet these objectives, organic agriculture farmers need to implement a series of practices that optimize nutrient and energy flows and minimize risk, such as: crop rotations and enhanced crop diversity; different combinations of livestock and plants; symbiotic Nitrogen fixation with legumes; application of organic manure; and biological pest control (Scialabba and Hattam, 2002). All these strategies seek to make the best use of local resources.

Organic farming is distinguished from conventional agriculture by exercising particular respect for human values, the environment, nature, and animal welfare, etc. This regard is incorporated in the basic principles of organic farming, as formulated by the International Federation of Organic Agriculture Movements. The main principles (IFOAM, 2002) for organic farming and food processing include:

1. The production of food of high quality in sufficient quantities,
2. Operation within natural cycles and closed systems as far as possible, drawing upon local resources,
3. The maintenance and long term improvement of the fertility and sustainability of soils,
4. The creation of a harmonious balance between crop production and animal husbandry,
5. The securing of high levels of animal welfare,
6. The fostering of local and regional production and supply chains, and
7. The provision of support for the establishment of an entire production, processing and distribution chain that is both socially and ecologically justifiable.

These basic principles provide organic farming with a platform for ensuring the health of environment for sustainable development, even though the sustainable development of mankind is not directly specified in the principles.

2.1 Organic agriculture and sustainable development

When the World Commission on Environment and Development presented their 1987 report, Our Common Future, they sought to address the problem of conflicts between environment and development goals by formulating a definition of sustainable development:

Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources (Harris, 2000). The United Nations report stated: ‘All case studies which focused on food production in this research where data have been reported have shown increases in per hectare productivity of food crops, which challenges the popular myth that organic agriculture cannot increase agricultural productivity.’ (UNEP-UNCTAD, 2008)

3. Comparison of organic and conventional agricultural system (Table 1)

The study carried out in the Central Valley of California shown that tomato yields were quite similar in organic and conventional farms. However, significant differences were found in soil health indicators such as nitrogen mineralization potential and microbial abundance and diversity which were higher in the organic farms. Nitrogen mineralization potential was three times greater in organic compared to conventional fields. The organic fields also had 28% more organic carbon (Drinkwater et al., 1995). One of the longest running agricultural trials on record (more than 150 years) are the Broadbalk Experiment at the Rothamsted Experimental Station in the United Kingdom. The trials compare a manure based fertilizer farming system (but not certified organic) to a synthetic chemical fertilizer farming system. Wheat yields are shown to be on average slightly higher in the organically fertilized plots (3.45 tones / hectare) than the plots receiving chemical fertilizers (3.40 tones / hectare). More importantly though, soil fertility, measured as soil organic matter and nitrogen levels, increased by 120% in the organic plots, compared with only 20% increase in chemically fertilized plots (Leigh and Johnston, 1997). Another trial's result from Sustainable Agriculture Farming Systems project (SFAS) at University of California, Davis shown the organic and low-input systems had yields comparable to the conventional systems in all crops which were tested - tomato, safflower, corn and bean, and in some instances yielding higher than conventional systems. Initially tomato yields in the organic system were lower in the first three years, but reached the levels of the conventional tomatoes in the subsequent years and had a higher yield during the last year of the experiment (Clark et al., 1999) (80 t/ha in the organic compared to 68 t/ha in the conventional). In one such study at South Dakota in Midwestern United States shows the higher average yields of soybeans (3.5%) and wheat (4.8%) in the organic compared to conventional farming system (Welsh, 1999). 21 year study compared plots of cropland grown according to both organic and conventional methods at Institute of Organic Agriculture and the Swiss Federal Research Station for Agroecology and Agriculture found that Organic yields were less by about 20% but Fertilizer, Energy and Pesticide use were less by 34%, 53% and 97% respectively as compared to conventional (Maeder et al, 2002). Also organic soils housed a larger and more diverse community of organisms. The study at Iowa State University assessed (Delate and Cambardella, 2004) the agro ecosystem performance of farms which found initially the yield was slightly lower (Organic corn & soybean yield averaged 91.8% & 99.6% of conventional respectively) in organic plots but in fourth year organic yield exceeded conventional for both corn and soybean crops (Delate et al, 2002). 30 Years Farming System Trial (FST) at Rodale Institute were shown organic corn yields 31% higher than conventional in years of drought (Pimentel et al, 2005).

These drought yields are remarkable when compared to genetically engineered "drought tolerant" varieties which saw increases of only 6.7% to 13.3% over conventional (non-drought resistant) varieties. Corn and soybean crops in the organic systems tolerated much higher levels of weed competition than their conventional counterparts, while producing equivalent yields. This is especially significant given the rise of herbicide-resistant weeds in conventional systems, and speaks to the increased health and productivity of the organic soil (supporting both weeds and crop yield). The study conducted by ETC Organic Cotton Programme in the district of Karimnagar, Andrha Pradesh India shown organic cotton yielded on par at 232 Kg seed cotton /acre vs. conventional cotton at 105 Kg/acre. The pest control expenses was observed about Rs. 220 and Rs. 1624 per acre for organic and in conventional cotton respectively (Daniel et al, 2005). Study at Washington State University compared yields, economics, soil quality, and other factors resulting from apples grown using organic, conventional, and integrated methods. After combining all of the sustainability indicators, the organic system ranked first (Reganold, 2006) in overall sustainability, the integrated second, and the conventional last. A survey conducted by Indian Institute of Soil Science on certified organic farms to evaluate the real benefits and feasibility of organic farming revealed that, on an average, the productivity of crops in organic farming was lower by 9.2% compared to conventional farming. But there was a reduction in the average cost of cultivation in organic farming by 11.7% compared to conventional farming. The average net profit of 22.0% higher in organic farming was observed where 20-40% premium provided. Besides this, overall improvement in soil quality was observed indicated an enhanced soil health and sustainability of crop production in organic farming systems (Ramesh et al, 2010).

Table 1: (Comparative studies illustrating difference between organically and conventionally managed agricultural field)

Author & Institute of Study	Length of Trial	Crops Grown	Findings
Drinkwater et al (1995) Central Valley of California	---	Tomato	• Yields were similar, • Higher microbial abundance and diversity, • Three times greater nitrogen mineralization potential, • 28% more organic carbon, • Crop more resistant to corky root disease
Leigh R. A., (1997) othamsted Experimental Station, UK	150yrs	Wheat	• Organic yields higher than conventional, • Soil fertility (in terms of soil organic matter and nitrogen levels) increased by 150% as compared to 20% increase in conventional
Clark S., et al (1999), SFAS Project, University of California, Davis	8yrs	Tomato, Safflower, Corn and Bean	• Tomato yields were lower in initial three years but exceeds later on, • Corn yield shown high variability
Welsh R. (1999), South Dakota in the Midwestern United States	6yrs	Soybean, Wheat	• Average organic yields of soybeans and wheat were 3.5% & 4.8% higher respectively than conventional
Maeder et al(2002), Institute of Organic Agriculture and Swiss Federal Research Station for Agroecology and Agriculture	21 years	Potatoes, Barley, Winter Wheat, Beet, and Grass Clover	• Organic yields were less by about 20%, Fertilizer use was less by 34% in organic as compared to conventional, • Energy use was less by 53% in organic as compared to conventional, • Pesticide use was less by 97% in organic as compared to conventional, • Organic soils housed a larger and more diverse community of organisms
Delate K. et al (2004), Iowa State University	4yrs	Corn and Soybean	• Initially both (corn & soybean) yields were slightly lower than conventional, • In fourth year organic yield exceeded conventional
Pimentel, et al(2005), Rodale Institute	22 yrs	Corn and Soybean	• Yields for corn and soy were the same between organic & conventional • Organic used 30% less energy, and less water • Organic resulted in less groundwater pollution & less erosion

			• Corn yields were lower by 1/3 in the organic fields during first 4 years • Yields in legume based system were 22% higher during drought years (1988-1998) • Soil carbon in organic system increased by 15-28% • Soil nitrogen in organic system increased by 8-15%. • Nitrate leaching was equivalent in both systems.
Daniel, et al (2005), ETC Organic Cotton Programme, India	1yr	Cotton	• Organic cotton yielded on par at 232 Kg seed cotton /acre vs. conventional cotton at 105 Kg/acre, • Pest control expenses in conventional were 8 times higher than organic, • organic more profitable
Reganold J. (2006), Washington State University	6yrs	Apple	• Tree growth was identical for all systems, • Cumulative yield showed no statistical difference, • organic system ranked first in overall sustainability
Ramesh P. et al (2010), Indian Institute of Soil Science	1yr	All crops	• Productivity of crops in organic farming is lower by 9.2% compared to conventional farming, • Average net profit was 22.0% higher in organic compared to the conventional farming due to reduced cultivation (by 11.7%) cost and premium available (20-40%).

4. Conclusion

A comprehensive review of a number of comparison studies on agricultural yields shows that in all of these studies organic production is equivalent to, and in many cases better than conventional farming practices. In some, overall lower yield also reported but the economy still better than the conventional agriculture practices due to the lower external inputs. Besides the yield comparisons, organic practices shows higher organic matter in soil, lower energy consumption, lower use of external inputs, better food quality, and also potential to address the global issues like climate change.

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