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RESEARCH ARTICLE

A Review of Organic farming as an Adaptive and Mitigation Strategy for Climate Change in a Developing Country

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Abstract

Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Climate change will dramatically alter global food production as most countries in the tropical and subtropical zones will suffer most, both from droughts and periodic floods which adversely affect agriculture. Agriculture is not only affected by climate change but also contributes to it, in that ten to twelve percent of global greenhouse gas emissions are due to human food production. In addition, intensive agriculture has led to deforestation, overgrazing and widespread use of practices that result in soil degradation. Organic agriculture in general requires less fossil fuel per hectare and kg of produce due to the avoidance of synthetic fertilizers. It aims at improving soil fertility and nitrogen supply by using leguminous crops, crop residues and cover crops, and the enhanced soil fertility leads to a stabilization of soil organic matter and in many cases to a sequestration of carbondioxide into the soils. This in turn increases the soil's water retention capacity, thus contributing to better adaptation of organic agriculture under unpredictable climatic conditions with higher temperatures and uncertain precipitation levels. More funding is needed for research on organic farming.

Introduction

Organic farming is the form of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control, to maintain soil productivity and control pests on a farm. It excludes or strictly limits the use of synthetic fertilizers and synthetic pesticides, plant growth regulators, livestock antibiotics, food additives, and genetically modified organisms (Lotter, 2003).

Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. It also combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM, 2008).

Climate change will dramatically alter global food production. The inequality in food supply between industrialized and developing countries is expected to increase, as the 40 poorest countries in the tropical and subtropical zones will suffer most, both from droughts and periodic floods (Tilman *et al*., 2006).

Agriculture is not only affected by climate change but also contributes to it (Niggli *et al.*, 2008). Ten to twelve percent of global greenhouse gas emissions are due to human food production. In addition, intensive agriculture has led to deforestation, overgrazing and widespread use of practices that result in soil degradation. These changes in land use contribute considerably to global CO_2 emissions. Sustainable agriculture and food supply systems are thus more urgently needed than ever before. They must boost the capacity of agricultural production to adapt to more unpredictable and extreme weather conditions such as droughts and floods, reduce greenhouse gas emissions in primary food production and halt or reverse carbon losses in soils (Van Oost *et al*., 2004).

In this review, organic farming is evaluated in the context of climate change. As simple answers cannot be given to such a complex and global problem, it is equally important to highlight recommendations for future development and research requirements in organic agriculture.

Agriculture as Cause and Victim of Climate Change

The current change in global climate is a phenomenon that is largely due to the burning of fossil energy (coal, oil, natural gas) and to the mineralization of organic matter as a result of land use. These processes have been caused by man's exploitation of fossil resources, clearing of natural vegetation and use of these soils for arable cropping (Gilbert, 2012).

These activities have primarily led to a measurable increase in the carbon dioxide (CO_2) content of the atmosphere, an increase which results in global warming, as CO_2 hinders the reflection of energy back into space, and thus more of it is trapped in the Earth's atmosphere (Gilbert, 2012). The global warming potential of methane is twenty times that of CO2, while that of nitrous dioxide is as much as 300 times greater. Thus, the greenhouse gas emissions from all sectors related to agriculture may potentially sum up to 25-30% of all GHG emissions (Barton *et al*., 2008).

Greenhouse gases emitted by the agricultural sector

According to the Intergovernmental Panel on Climate Change (IPPC), the annual amount of greenhouse gases emitted by the agricultural sector is estimated at between 5.1 and 6.1gigatonnes CO_2 equivalents in 2005 (Barker *et al*., 2007). This represents approximately 10–12% of total greenhouse gas emissions. Of these emissions, methane accounts for 3.3 Gt equivalents and nitrous oxide for 2.8 Gt CO_2 equivalents annually, while net emissions of CO_2, at only 0.04 Gt CO_2 equivalents per year, are small. Agriculture is the main emitter of nitrous oxides and methane according to current practice and knowledge.

Emissions of nitrous oxide originate mainly from:

• High soluble nitrogen levels in the soil from synthetic and organic nitrogen sources (fertilizers).
• Animal housing and manure management.

The main sources of methane emissions are:

• Enteric fermentation by ruminants (e.g. cows, sheep, goats).
• Anaerobic turnover in rice paddies.
• Manure handling.
• Compaction of soils resulting from the use of heavy machinery.
• Biomass burning, e.g. from slash-and-burn agriculture, emits both methane and nitrous oxide.

The Potential of Organic Farming to Mitigate Climate Change

Organic Agriculture can help to mitigate climate change by
a) Reducing emissions of greenhouse gases (GHGs) and
b) By sequestering CO_2 from the atmosphere in the soil.

REDUCTION OF GREENHOUSE GAS EMISSIONS

Organic farming has lower global warming potential

The global warming potential (GWP) of agricultural activities can be defined as greenhouse gas (GHG) emissions in CO_2 equivalents per unit land area or per unit product. The global warming potential of organic farming systems is considerably smaller than that of conventional or integrated systems when calculated per land area.

ORGANIC FARMING SEQUESTERS CO_2 IN THE SOIL

Arable cropland and permanent pastures lose soil carbon through mineralization, erosion (water and wind-driven) and overgrazing. Global arable land loss is estimated at 12 million hectares per year, which is 0.8% of the global cropland area (1,513 million hectares) (Pimentel *et al*., 1995). If agricultural practices remain unchanged, the loss of organic carbon in typical arable soils will continue and eventually reach a new steady state at a low level.

The application of improved agricultural techniques (e.g. organic farming, conservation tillage, agroforestry), however, stops soil erosion (Bellamy *et al*., 2005) and converts carbon losses into gains by:

• The use of green and animal manure.
• Soil fertility-conserving crop rotations with intercropping and cover cropping.

- Composting techniques.
- Agroforestry

Does Organic Farming have Potential to Adapt to Climate Change?

Organic systems are highly adaptive to climate change due to

- The application of traditional skills and farmers' knowledge,
- Soil fertility-building techniques and
- A high degree of diversity
- Soils under organic management retain significantly more rainwater (Lotter *et al*., 2003). This significantly reduces the risk of floods

What are the Weaknesses of Organic Agriculture in the Context of Climate Change?

Criticism No. 1: Organic farming is less productive

Agronomically difficult crops as a challenge

One major criticism of organic agriculture is that productivity is lower compared to intensive conventional agriculture. Under geoclimatic conditions that allow for a very high yield, in the case of some crops the relative advantage of organic agriculture in terms of energy consumption per land area compared to conventional production may switch to the contrary when calculated on the basis of crop or livestock yield. This is particularly true in the case of highly demanding crops such as potatoes, grapes fruits and horticultural crops especially from greenhouse production (Nemecek *et al*., 2005; Bos *et al*., 2006; Comrack, 2000). Pest, disease and weed management problems relating to these crops have not yet been resolved satisfactorily. Consequently, the yield for these crops is too low and the energy input, even though relatively low on a land area basis, becomes relatively high when applied to a crop unit. With more research into organic agriculture, however, progress may be expected in this field.

POSSIBLE WAY OUT

Better technology transfer could improve organic yields

The productivity of organic agriculture is often underestimated by many scientists and policymakers.

Organic agriculture represents a very productive food supply system that relies on recycling strategies. Badgley *et al*. (2007) modelled the yields stated in 293 on-farm and on-station publications and concluded that, compared to high-input agriculture in developed countries, the average yields in organic crop and livestock production are 92% of those in conventional agriculture.

Criticism No. 2: High dependency on nutrients derived from livestock

Some critics are concerned about the dependency of organic cropping upon nutrients deriving from livestock. This criticism, however, underestimates manure as a valuable and potentially useful resource. Moreover, this is not a relevant weakness since the numbers of animals kept in agriculture depends mainly on consumer demand.

POSSIBLE WAY OUT

In order to reduce greenhouse gas emissions, efficient and direct recycling of manure and slurry is the best option, since it avoids long-distance transport and consumption of energy for synthetic fertilizer production. The combination of crop and livestock production is currently the most efficient way of bringing organic 'waste' from livestock production back into the carbon stock of the soils and use it as a locally available resource for crop fertilization and enhancing soil quality.

Conclusions

- Organic agriculture has considerable potential for reducing emissions of greenhouse gases.
- Organic agriculture in general requires less fossil fuel per hectare and kg of produce due to the avoidance of synthetic fertilizers. Organic agriculture aims at improving soil fertility and nitrogen supply by using leguminous crops, crop residues and cover crops.
- The enhanced soil fertility leads to a stabilization of soil organic matter and in many cases to a sequestration of carbon dioxide into the soils.
- This in turn increases the soil's water retention capacity, thus contributing to better adaptation of organic agriculture under unpredictable climatic conditions with higher temperatures and uncertain precipitation levels. Soil erosion, an important source of CO_2 losses, is effectively reduced by organic agriculture.

• More funding is needed for research on organic farming

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