Introduction to the Special Issue: Towards A More Sustainable Agriculture

Maurizio G. Paoletti¹; Tiziano Gomiero¹; David Pimentel¹

¹ Laboratory of Agroecology and Ethnobiology, Department of Biology, Padova University, Padova, Italy
² College of Agriculture and Life Sciences, Cornell University, Ithaca, New York, USA

Online publication date: 29 April 2011
Introduction to the Special Issue: Towards A More Sustainable Agriculture

Maurizio G. Paoletti,1 Tiziano Gomiero,1 and David Pimentel2

1 Laboratory of Agroecology and Ethnobiology, Department of Biology, Padova University, Padova 35121, Italy
2 College of Agriculture and Life Sciences, Cornell University, Ithaca, New York 14853, USA

Agriculture provides food, fiber, construction materials, biomass, and “green energy.” It also contributes to an environmentally-friendly environment. Our societies are totally dependent upon agriculture and the photosynthetic pathway contributed by sunlight.

When humans began to rely on agriculture for their subsistence, civilizations flourished while humans spread all over the globe, transforming ecosystems to provide for their ever-increasing needs (Diamond, 1998; Bellwood, 2005; Montgomery, 2007a; Murphy, 2007; Ponting, 2007). According to Ruddiman (2005a, 2005b), early human activity, such as forest conversion to agricultural land, extensive use of fire, and wet rice cultivation, resulted in high Green House Gasses emission (GHGs), able to alter the earth climate long before industrial revolution took place.

Agricultural societies had to deal with the need to feed an growing population and to cope with the increasing complexities of their societies (Tainter, 1988; Johnson and Earle, 2000). As populations increased, pressure on the agricultural system led to reduced soil fertility and threatened its sustainability. Soil erosion led to soil exhaustion (loss of organic matter and its fertility) that impaired agro-ecosystem resilience, making it difficult to cope with the effects of climate extremes. Among the practices that led to the mismanagement of the soil were deforestation, fires, tillage, short rotation, irrigation (leading to the salinization of the soil), and a tendency to adopt monoculture rather than crop diversity (King, 1911; Carter and Dale, 1974; Tainter, 1988; Hillel, 1991; Diamond, 2005; Montgomery, 2007a; Ponting, 2007). Carter and Dale (1974) suggested that civilizations tend to collapsed in about 20 generations, apart from those relying, for soil fertilization, on river.

In the twentieth century, with the advent of fossil fuels, agriculture experienced an incredible boost. Thanks to chemical fertilizers and pesticides and the availability of other sources of energy, this helped to increase crop yields. In addition, the new high yielding varieties (HYVs) (or high-response varieties) developed in the 1960s by Norman Borlaug (1914–2009, Nobel Peace Price in 1970) and colleagues, helped to increase crop yields (Borlaug, 1970; Conway, 1998). With the “Green Revolution” the productivity of the main agriculture crops increased up to 4–5 times, helping to cope with the severe food scarcity and famine hitting many highly populated developing countries (Conway, 1998; Smil, 2000; Tilman et al., 2001; Pimentel and Pimentel, 2008). The main characteristics of the HYVs can be summarized as: having shorter stems than traditional cultivars, being genetically homogeneous and much more productive under high rates of fertilizers (e.g., synthetic nitrogen). However, HYVs were also weaker than their traditional relatives and more prone to pests and diseases (Conway, 1998).

In the last half century, the great abundance of cheap food (along with medical advances) led to increasing population growth, and contrary to the hopes of the green revolution, whose goal was to put an end to hunger, the FAO at present estimates that 1.02 billion people are hungry and undernourished worldwide in 2009. This represents more hungry people than at any time since 1970 (FAO, 2009; UNEP, 2009). When considering malnutrition in all its facets, it has been estimated that, at present, about 60% of the world population can be considered malnourished (Pimentel and Pimentel, 2008). It was Borlaug himself that warned, in his Nobel lecture, that unless the rate of human reproduction was curbed, the success of the Green Revolution would only be ephemeral (Borlaug, 1970). Some scholars argue, however, that remaining malnutrition is more a matter of access to food rather than one of insufficient availability and that there are additional social-political issues that play an important role in this problem (Sen, 1982; Conway, 1998; Smil, 2000; FAO, 2009).

Over the next decades the world’s population is expected to grow from 6.8 billion in 2008 (medium estimates) to 8.3 billion by the 2030, and to 9.2 billion by the 2050 (Cohen, 2003; UN, 2007; FAO, 2008; UNEP, 2009). Scenario analysis indicates a possible stop to population growth by the end of the century (Lutz et al., 2001, 2004). Other scholars, however,
remain skeptical (e.g., Hopfenberg and Pimentel, 2001) arguing that, contrary to the widely held belief that food production must be increased to feed the growing population, experimental and correlational data indicate that human population growth varies as a function of food availability, so that by increasing food production the effect will be an increase in the human population.

Recent studies suggest that the world will need 70 to 100% more food by 2050 (FAO, 2008; World Bank, 2008). So a new challenge lies ahead: to find a means to feed 9 billion with less food by 2050 (FAO, 2008; World Bank, 2008). So a new population.

and correlational data indicate that human population growth must be increased to feed the growing population, experimental and correlational data indicate that human population growth varies as a function of food availability, so that by increasing food production the effect will be an increase in the human population.

Increasingly, intensive agricultural practices are affecting the very sustainability of our support system, the soil (Pimentel et al., 1995; Montgomery, 2007b). Croplands and pastures already occupy about 50% of the land surface (Foley et al., 2005), with large effects on biodiversity conservation (Paoletti et al., 1992; Krebs et al., 1999; Millennium Ecosystem Assessment, 2005). Agriculture accounts for 70% of water used by human activities (Molden, 2007). The use of agrochemicals is costly in terms of energy use (Pimentel and Pimentel, 2008), represents a threat to biodiversity and human life (Lipsitch et al., 2002; Lyons, 2009; Vitousek et al., 2009; Pimentel, 2010), and can cause a high level of water pollution (Molden, 2007; Moss, 2008). It is therefore urgent to find more ecological ways of limiting pests (Altieri and Nicholls, 2004; Gurr et al., 2004; Pimentel and Cilvetti, 2007). At the same time, agricultural practices should reduce both their environmental impact and their use of non-renewable resources (e.g., fossil fuel energy) (Millennium Ecosystem Assessment, 2005; Pimentel and Pimentel, 2008).

Vast industrialized agriculture also contributes greatly to impoverished crop biodiversity, with the loss of a large number of agricultural species and varieties (Fowler and Hodgkin, 2005). A cultural aspect that may be worth mentioning is that when Western agriculture package is transferred to other continents, it tends to displace, or overlook, many sorts of traditional local resources—such as insects and other arthropods, earthworms, small vertebrates and wild plants (insects and earthworms, for instance, may total more than 3,000 kg/ha; Pimentel and Pimentel, 2008). These local resources can play an important role in guaranteeing food security in poor rural areas, but are often neglected because of the Western perception that these are not “proper food” for people (Paoletti and Bukkens, 1997; Paoletti, 2005; Ochatt and Jain, 2007).

We are aware that a topic such as agriculture sustainability is broad and highly complex (Smil, 2000; Giampietro, 2004; Francis et al., 2006; Bohlen and House, 2009; UNEP, 2009; NRC, 2010). It includes aspects ranging from ecology to genetics, from agronomy to soil management, from economics to politics. The point we wish to make with this special issue is to offer some additional ideas and comments on some issues in the field of sustainable agriculture.

The first two papers address directly the sustainability issue.

The first paper, “Is there a need for a more sustainable agriculture?” (Gomiero and colleagues), reviews a number of problems concerning the impact of conventional agriculture on the environment and soil, and discusses some theoretical approaches and techniques that may offer useful strategies for a more sustainable agriculture. The second paper, “Resources and cultural complexity: Implications for sustainability” (Tainter), addresses the relations between agriculture, society complexification and the pattern of collapse associated with complex societies. Tainter defines sustainability as a matter of problem solving and a process of continuous adaptation. He points out that, paradoxically, as problems arise, addressing these problems requires “complexification” of the society and in turn more resources consumption. Some ideas concerning the possibility to deal with the sustainability issue are presented.

The second pair of papers deals with the use of energy in agriculture, and the sector’s dependence on fossil fuels. The paper by Pimentel, “Food for thought: A review of the role of energy in current and evolving agriculture,” analyzes the energetic costs of food production, while the paper by Arizpe and colleagues, “Food security and fossil energy dependence: An international comparison of the use of fossil energy in agriculture (1991–2003),” reviews global trends in energy consumption in agriculture.

A third group of papers deals with management issues and focuses on possible practices for achieving more sustainable agriculture.

The paper by Francis and Porter, “Ecology in sustainable agriculture practices and systems,” reviews a number of practices that can be employed to improve agricultural efficiency and sustainability.

Pest control is a key issue in agriculture management, and pesticide use a major environmental impact. Eckström and Ekbom, “Pest control in agro-ecosystems: An ecological approach,” review the recent achievements in the field of natural pest control and how this can contribute to reducing the environmental impact of agriculture.

During recent decades organic farming has achieved wide attention both from consumers and policy makers because of its call for promoting an agriculture free from agrochemicals and based on ecological practices, and for its concern for the preservation of biodiversity. The paper by Gomiero and colleagues, “Environmental impact of different agricultural management practices: Conventional vs. organic agriculture,” summarizes this story and the foundation of the organic movements and reviews research works assessing the achievement of organic farming vs. conventional farming for a number of environmental issues.

Over time, the number of crops and local varieties have drastically reduced in most regions, with the result that fewer plants and animals now compose the actual base of our food. The paper “A heuristic framework for identifying multiple ways of
supporting the conservation and use of traditional crop varieties within the agricultural production system” by Jarvis and colleagues, addresses this problem and discusses the different ways of supporting farmers and farming communities in the maintenance of traditional varieties and crop genetic diversity within their production systems.

A fourth selection of papers deals with food quality and the knowledge about the use of semi-domesticated and wild plants. Whether organically grown crops have more nutritional properties than conventional crops is matter of debate. The paper by Brandt and colleagues, “Agroecosystem management and nutritional quality of plant foods: The case of organic fruits and vegetables,” reviews the present knowledge about the nutritional characteristics of organic products. Turner and colleagues in “Edible and tended wild plants, traditional ecological knowledge and agroecology,” explore local knowledge of semi-domesticated or tended and wild plants and their nutritional as well as their possible economic role.

The closure of the special issue is provided by Francis and colleagues with a paper titled “Innovative education in agroecology: Experiential learning for a sustainable agriculture,” which reviews recent experiences in the field of agriculture education. It is vital that we develop sound agricultural practices, if we want to have a new generation of scientists able to deal with the complex field of sustainable agriculture.

We wish to thank all the authors who participated in this project, as well as the editors of CRPS for their interest and sensitivity on this vital issue.

REFERENCES


