Chapter 2

Organic Farming as an Essential Tool of the Multifunctional Agriculture

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Additional information is available at the end of the chapter

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Abstract

This chapter aims at shedding light on the annals of organic farming and at defining its past and present meaning. Low-profile attempts were made in the first half of the last century when it comes to organic farming as it developed almost independently in the German and English speaking world. Organic farming has been established as a promising and innovative method of meeting agricultural needs and food production with respect to sustainability (climate change, food security and safety, biodiversity, rural development). Its value in terms of environmental benefits is also acknowledged. The differences between organic and conventional food stem directly from the farming methods that were used during the food items' production. Many people are unaware of some of the differences between the two practices. Agriculture has a direct effect on our environment, so understanding what goes into it is important. There are serious differences between organic and conventional farming; one of the biggest differences that is observed very frequently across all research between the two farming practices is the effect on the land. Conclusively, organic farming is a form of agriculture that relies on ecosystem management and attempts to reduce or eliminate external agricultural inputs, especially synthetic ones. It is a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity.

Keywords: Sustainability, environment, health, fertility

1. Introduction: History of organic farming

1.1. Growth and spread of the organic ideals

Many agricultural dogmas claim to strive towards sustainability [1]. Organic farming is the pinnacle of these models, and probably the one that is most acknowledged worldwide in the scientific and political arenas [2, 3], as well as by consumers as a whole. Today, organic farming is a legitimate system due to its history and evolution of practices, and rules and regulations [4, 5, 6, 7].

Organic farming is "a form of agriculture that uses fertilizers and pesticides (which include herbicides, insecticides and fungicides) if they are considered natural (such as bone meal from animals), but it excludes or strictly limits the use of various methods, including synthetic petrochemical fertilizers and pesticides; plant growth regulators such as hormones; antibiotic use in livestock; genetically modified organisms etc." [8]. As a result, it relies on techniques such as crop rotation, green manure, compost, and biological pest control.

Organic farming has dramatically grown in importance and influence worldwide throughout the years. A few statistics tell a fragment of the story: from almost negligible levels during the 1980s, the area of organic farms worldwide spanned to an estimated 43.1 million hectares in 2013 [9]; the worldwide organic market size was worth 54 billion euros in the same year [10]. However, these numbers depict only a part of what organic farming has become; scientists, educators, and agricultural policy makers have been making a change that formally began during the late 1970s. The growth of research on organic farming has been particularly striking, and the number and variety of organic curricula and degrees offered at universities in many countries are vast. At the first International Scientific Conference of the International Federation of Organic Agriculture Movements (IFOAM), held in Switzerland in 1977, a total of 25 presentations were offered. When the IFOAM conference returned to Switzerland in 2000, that number had multiplied more than 20 times, to well over 500 [11]. Before the 1970s, funds for organic research were extremely limited; today, significant public money is available in many countries: Denmark, France, Germany, Sweden, Switzerland, and the Netherlands are all reported to spend millions per year on organic research [12]. An important component of the advancement of organic farming has been its global spread. Five countries were represented when IFOAM was organized in 1972, and by the late 1990s, it had members from over 100 countries. IFOAM's scientific conferences, which until the mid-1980s had only been held in Western Europe and North America, have since been held in countries as diverse and dispersed as Burkina Faso, Australia, Hungary, and Brazil, among others. Further evidence that organic farming has gone global is that the UN Food and Agriculture Organization has been involved in it since 1999, with activities that include market analysis, environmental impact assessments, improving technical knowledge, and development of standards through the Codex Alimentarius Commission [13]. The United Nations Conference on Trade and Development has been involved in global trade of organic foods since 2001, particularly in assisting developing countries in increasing their production [14].

1.2. History

The concept we know today as 'organic farming' is a mixture of different views coming mainly from German and English-speaking societies. These ideas arose at the end of the 19th century, and between the two World Wars, as intensive and mechanized farming faced a crisis in the form of soil degradation, poor food quality and the decay of rural social life and traditions.

Inappropriate use of mineral fertilizers was disturbing plant metabolism, making them susceptible to pathogens and insect pests. At the same time, effective pesticides had not yet been developed. Physiologically acidic mineral fertilizers acidified the soil and brought about diminished root growth and degradation of the soil structure. Soil compaction caused by the use of machinery and reduced organic manuring caused droughts, and soils experienced a decline in fertility – referred to as “soil fatigue” (Bodenmüdigkeit) [15]. Despite the increased use of mineral fertilizers, agriculture suffered a dramatic drop in yields (up to 40% in countries like Germany) after World War I; only at the end of the 1930s – after more than 15 years – did yields reach pre-war levels [16].

Some consumers were worried about declining food quality: food that did not stay fresh, tasteless vegetables and fruits, and pesticide residue based on toxic heavy metals. Increased use of mineral fertilizers and pesticides was discussed by the public as a major cause of this decline. For example, an assumption that an elevated level of potassium in cancer cells was caused by the increased amount of potassium in fertilizers was not something unthought-of. Scientists such as Robert McCarrison in the UK or Werner Schuphan and Johannes Görbing in Germany confirmed some of these suspicions, such as lower vitamin levels in fruits and vegetables caused by increased nitrogen fertilization [17, 18]. Finally, the social and economic situation in the countryside changed dramatically with the mechanization of agriculture, industrialization of the food sector, and import of agricultural products. An imbalance arose between the urban centers; severe economic problems caused by low prices (due to imports) and indebtedness (due to purchase of machines, fertilizers, and pesticides) forced many small and medium-sized farms to give up. As a result, there was a general decline in rural tradition and lifestyle.

As a solution to this crisis, organic farming pioneers offered a convincing, science-based theory during the 1920s and 1930s that evolved into a successful farming system during the 1930s and 1940s. But it was not until the 1970s, with growing awareness of an environmental crisis, that organic farming attracted interest in the wider worlds of agriculture, society, and politics. The leading strategies that proposed to achieve sustainable land use included a biological concept of soil fertility, intensification of farming by biological and ecological innovations, renunciation of artificial fertilizers and synthetic pesticides to improve food quality and the environment and, finally, concepts of appropriate animal husbandry.

At the annual meeting of the American Association for the Advancement of Science (AAAS) in 1974, a panel of scientists targeted the “organic food myth”, calling it “scientific nonsense” and the domain of “food faddists and eccentrics”. They also blamed such “pseudoscientists” for causing panic among the public with regard to paying more for food [19] and also mentioned that the “organic myth” was counterproductive to human welfare, because it leads to a rejection of procedures that are needed for the production of nutritious food at “maximum efficiency” and was “eroding gains of decades of farming advancements”. However, 7 years later, the journal of this same AAAS published a major research paper that found organic farms to be highly efficient and economically competitive when compared to conventional farming [7].

2. Comparison of organic and conventional farming system

In the recent years, agriculture has been oriented towards industrial and notably intensive farming practices aimed at ensuring enough food for humanity. However, these types of farming practices also caused several negative environmental impacts such as decreasing biodiversity. Many agroecosystems intensified their activities and became highly mechanized, while those unable to do so became increasingly marginalized and were sometimes forced to abandon their land, causing evenly destructive effects for biodiversity [20].

Currently, it is globally imperative that the increasing demand for food be met in a manner that is socially fair and ecologically sustainable over the long run. It is possible to design farming systems that are similarly productive and that enhance the provisioning of ecosystem services such as biodiversity, soil quality and nutrient, control of weeds, diseases and pests, energy efficiency, and the reduction of global warming potential, as well as resistance and resilience to climate change and crop productivity [21].

Organic farming is a system that favors soil fertility by maximizing the efficient use of local resources, while foregoing the use of agrochemicals and genetically modified organisms. The high quality of organic food and its added value based on a number of farming practices relies on ecological cycles, and it focuses on declining the environmental effect of the food industry, maintaining long-term sustainability of soil and reducing to a minimum the use of nonrenewable resources [22].

Organic farming practices have been launched to reduce the environmental impacts of agriculture. The results of studies that compare the environmental impacts of organic and conventional farming in Europe show that organic farming has a positive impact on the environment. Important differences between the two farming systems include soil organic matter (SOM) content, nitrogen leaching, nitrous oxide emissions, energy use, and land use. Most of the studies that compared biodiversity in organic and conventional farming showed lower environmental impacts from organic farming [23].

Furthermore, organic farming appears to perform better than conventional farming and also provides other important environmental advantages such as curbing the use of harmful chemicals and their spread in the environment and along the trophic chain, and reducing water use [22].

- *Health*

Organic practices contribute to better health through reduced pesticide exposure for all and increased nutritional quality in food products. In order to understand the importance of consumption of organic food from the viewpoint of toxic pesticide contamination, we should look at the whole picture: from the farmers who do the valuable work of growing food, to the waterways from which we drink, the air we breathe, and the food we eat. Organic food can nourish us and keep us healthy without causing the toxic effects of chemical agriculture [24, 25].

The population groups most affected by pesticide use are farmers. These people live in communities near the application of toxic pesticides, where pesticide drift and water contamination are common. Farmers, both pesticide applicators and fieldworkers who tend to and harvest the crops, come into frequent contact with such pesticides. Organic farming does not utilize these toxic chemicals, and thus eliminates this enormous health hazard to workers, their families, and their communities [25, 26].

Acute pesticide poisoning among farmers is only one aspect of the health consequences of pesticide exposure. Many farmers spend time in the fields, resulting in prolonged exposure, and some studies have reported increased risks of certain types of cancers among farmers as a consequence. The emerging science on endocrine disrupting pesticides reveals another chronic health effect of pesticide exposure [25, 27].

- *Environment*

Organic farming is often perceived to have generally beneficial effects on the environment compared to conventional farming [28, 29]. More specifically, organic food production eliminates soil and water contamination. Since organic food production strictly avoids the use of all-synthetic chemicals, it does not pose any risk of soil and underground water contamination like conventional farming, which uses tons of artificial fertilizers and pesticides. Also, organic food production helps preserve local wildlife; by avoiding toxic chemicals, using mixed planting as a natural pest control measure, and maintaining field margins and hedges, organic farming provides a retreat to local wildlife rather than taking away their natural habitat like conventional agriculture [30].

Agrobiodiversity is an important aspect of biodiversity that is directly influenced by different production methods, especially at the field level. It can also supply several ecosystem services to agriculture, thus reducing environmental externalities and the need for off-farm inputs. Moreover, organic farming helps conserve biodiversity. Avoidance of chemicals and use of alternative, all natural farming methods have been shown to help conserve biodiversity as it encourages a natural balance within the ecosystem and helps prevent the domination of a particular species over the others [31].

Various different approaches have been used in order to compare environmental impacts of farming systems, such as organic and conventional. Several studies have focused on biodiversity [31, 32], land use [33], soil properties [34, 35], or nutrient emissions [36, 37]. Life cycle assessment (LCA) studies have used a product approach to assess the environmental impacts of a product from input production up to the farm gate [38, 39]. According to the literature, Mondelaers et al. (2009) [40] used the meta-analysis method to compare the environmental impacts of organic and conventional farming, examining land-use efficiency, organic matter content in the soil, nitro-phosphate leaching into the water system, greenhouse gas (GHG) emissions, and the effect on biodiversity [23].

In a review of literature, Hole et al. (2005) [31] compared biodiversity in organic and conventional agroecosystems. They found that organic farming generally had positive impacts on biodiversity. However, they concluded that it is still unclear whether conventional farming with specific practices for biodiversity conservation (i.e., agri-environmental schemes) can provide higher benefits than organic farming. More studies published after 2003 supported the findings of Hole et al. (2005) [31] and Bengtsson et al. (2005) [41], but none found organic farming to have negative impacts on biodiversity. More specifically, herbaceous plant richness has been widely found to be higher in organic farms compared with conventional farms [42, 43], and several studies showed that landscape had more important impact on biodiversity than farming practices [44, 45]. It has also been found that organic farming, without additional practices, is not adequate for conserving some animal species [23, 44, 46, 48].

The main reason for the reduction of agricultural biodiversity during the last decades has been the change in agricultural landscapes [48, 49]. In Europe, formerly heterogeneous landscapes with a mix of small arable agroecosystems, semi-natural grasslands, wetlands, and hedgerows have been replaced in many areas by largely homogeneous areas of intensively cultivated farms [50]. This has resulted in declines in biodiversity and has caused an important loss of species [23, 51].

Regarding the soil ecosystem, Tuomisto et al. (2012) [23] had found that organic matter across all the cases was 7% higher in organic farms compared to conventional farms. The main explanation for higher organic matter contents in organic systems was that they had higher organic inputs such as manner or compost. Other explanations for higher SOM levels in organic systems were less intensive tillage and inclusion of leys in the rotation [52, 53]. Gosling and Shepherd (2005) [54] observed lower organic matter contents in organic farms by higher yields, and thus, higher crop residue leftovers in conventional systems, which can compensate the lower external organic matter inputs. Furthermore, they argued that leys do not necessarily contribute to the increase of organic matter because they have a low carbon–nitrogen ratio and, therefore, organic matter decomposes quickly.

According to some studies [55, 56], the main explanation for lower nitrogen leaching levels from organic farming per unit of area was the lower levels of nitrogen inputs applied. Raised nitrogen leaching levels were explained by bad synchrony between the nutrient availability and crops' nutrient intake [57]. Notably, after incorporation of leys, the nitrogen losses tend to be high [58].

In conclusion, organic farming is a method of crop and livestock production that considered an environmentally friendly agriculture practice and a holistic approach involving several requirements and prohibitions from a regulatory point of view, and receives primarily from European countries additional agri-environmental payments for ecosystem services such as biodiversity. In several countries, payments are available as single biodiversity measures such as insectary strips, hedgerows, crop rotation, or the retention of semi-natural areas in agri-environmental programs that also focus on conventional farming.

3. Organic farming, conservation agriculture, and sustainability

This chapter shows the connection between organic farming and sustainability-conservation models, how this interplay has evolved during the past years, and, more importantly, its future directions. Various agricultural models claim to achieve sustainability. Organic farming is one of those candidate models, and probably the most widely known and accepted on an international level. It is recognized in the scientific and political areas as well as by society as a whole. Organic farming has been established as a promising and innovative method of meeting agricultural needs and food production with respect to sustainability (climate change, food security and safety, biodiversity, rural development). Its value in terms of environmental benefits is also acknowledged.

Organic agriculture is developing rapidly, and statistical information is now available from 138 countries in the world. Its share of agricultural land and farms continues to grow in many countries. According to the latest survey on organic farming worldwide, almost 30.4 million hectares are managed organically by more than 700,000 farmers. Most of this land is in Latin America, followed by Asia, Africa, and Europe [9].

Organic farming works in harmony with nature rather than against it, and it involves using techniques to achieve good crop yields, without harming the natural environment, or the people who live and work in it. The methods and materials that organic farmers use are summarized as follows:

To keep and build good soil structure and fertility:

- Recycled and composted crop wastes and animal manures
- Right soil cultivation at the right time
- Crop rotation
- Green manures and legumes
- Mulching on the soil surface

To control pests, diseases, and weeds:

- Careful planning and crop choice
- The use of resistant crops
- Good cultivation practice
- Crop rotation
- Encouraging useful predators that eat pests
- Increasing genetic diversity
- Using natural pesticides

Organic farming also involves:

- Careful use of water resources
- Good animal husbandry

Future global food security relies not only on high production and access to food but also on the need to address the destructive effects of current agricultural production systems on ecosystem services [65] and to increase the resilience of the production systems to the effects of climate change. Conservation agriculture (CA) enables the sustainable intensification of agriculture by conserving and enhancing the quality of the soil, leading to higher yields and the protection of the local environment and ecosystem services [67].

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels, while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

CA is characterized by three principles which are linked to each other, namely:

1. Continuous minimum mechanical soil disturbance (i.e., no tilling and direct planting of crop seeds).

2. Permanent organic soil cover.

3. Diversification of crop species grown in sequence and associations [62].

It has generally been demonstrated that CA allows yields to increase while improving soil and water conservation, and reducing production costs [60, 64]. In addition, CA has been shown to work successfully in a variety of agroecological zones and farm sizes. Indeed, another advantage associated with CA is that it can be applied to different farming systems, with different combinations of crops, sources of power and production inputs.

There is no real dispute that sustainable agriculture and organic farming are closely related terms. There is, however, some disagreement on the exact nature of this relationship; for some, the two are synonymous, while for others, equating them is misleading. Lampkin's definition of organic farming, quoted earlier, talks of sustainable production systems. Having provided his definition, he goes on to state: "...sustainability lies at the heart of organic farming and is one of the major factors determining the acceptability or otherwise of specific production practices." Similarly, Henning et al. precede their definition of organic farming, quoted above, by claiming that "it could serve equally well as a definition of 'sustainable agriculture'" [59]. Rodale even suggested that "sustainable was just a polite word for organic farming" [63]. Some of the research that has been carried out regarding the historical relationship between agricultural systems and the sustainability of the societies they support illustrates the point that a farming system need not be modern, mechanized, and using synthetic chemicals to be profoundly unsustainable [61].

Part of the difficulty in assessing the sustainability of agricultural systems, is the fact that both the units of measurement and the appropriate scales for measurement differ both within and across the commonly identified economic, biophysical and social dimensions of sustainability. For example, consideration of the effects of organic production on farm margins, soil fertility, and rural employment are difficult to combine in an overall measure. They are not so problematic if the effects are all in the same direction, but when one starts to consider trade-offs, as one indicator increases and another falls across different dimensions, then this factor becomes more significant. This is an issue which will not be solved simply by greater knowledge of the impacts of different production systems; even with complete information regarding impacts, one will still have to consider trade-offs with movement towards targets in some respects accompanied by reverses in others [61].

4. Organic practices

Throughout the years, organic farming has evolved in a diverse manner. Many sub-schools and sub-dogmas have appeared. Two of the most important, biointesive farming and permaculture, are discussed below:

4.1. Biointesive farming

Biointensive agriculture aims to result in maximum yields from the minimum area of land, while simultaneously improving and maintaining the fertility of the soil, as well as abiding by the rules of organic farming all the time. It is particularly designed for the small-scale grower. Biointensive cropping strategies (i.e., polycultures) are usually labor intensive [68].

4.1.1. Permaculture

Permaculture emphasizes eco-design [69]. Sepp [70] defines permaculture as a system in which every element fulfills multiple functions, and every function is performed by multiple elements. Energy is used practically and efficiently with a great focus on renewable forms, and diversity is favored instead of monoculture.

4.2. Crop rotation

Crop rotation is a very important piece of all organic cropping systems because it provides the basic function of keeping soils healthy, an efficient way to control pests, and other benefits. Crop rotation is defined as changing the type of crop grown on a particular piece of land from year to year [71]. There are both cyclical rotations, in which the same sequence of crops is repeated on the same field, and noncyclical rotations, in which the sequence of crops is diversified to meet the changing needs of the farmer.

Good crop rotation requires long-term strategic planning. However, planning that is too long term may prove futile as choices can be affected by changes in weather, in the market, labor expenses, and other factors. Conversely, lack of planning can lead to serious problems – for example, the buildup of soil-borne diseases of a critical crop, or imbalances in nutrients [71]. Problems like the ones mentioned above often take several years to become noticed and can catch even experienced farmers by surprise. In fact, rotation problems usually do not develop until well after the transition to organic cropping. Fallowing is also a noted part of crop rotation.

The design of a diverse crop rotation is the key to soil nutrients, weed, pest, and disease management. To achieve even some of these benefits of crop rotation, great focus on management is required, since diversity simply as a goal may lead to losses in production and productivity [72]. Therefore, there is a need for functional diversity [73]. In mixed intercropping, crop cycles tend to be similar to allow simultaneous management of the components (e.g., grass/clover leys or cereal with grain legumes), or completely different to allow separate management (e.g., cereals intercropped with forage legumes). Extremes of mixed intercropping systems can be seen in agroforestry [74] or perennial polyculture [75, 76].

Principles guiding the spatial arrangement of crops in polyculture are also well developed, dominantly originating from horticulture; they have been tested through research and developed by trial and error [77, 78, 79] of studies of traditional cropping systems [80, 81, 82].

4.3. No till and conservation till farming

In zero tillage, the soil is left undisturbed from harvest to planting, except for nutrient supply. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, as well as in-row chisels [83]. Weed control is accomplished primarily with herbicides.

Conservation tillage is defined as tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting (CTIC and Conservation Technology Information 1998). There are various benefits to this practice, with the most important being economic (conservation tillage operations reduce costs) and environmental (reduced cultivation implies reduced energy inputs [84], thereby ensuring less pollution and less disturbed soil, while organic matter accumulation is increased and CO_2 releases to the atmosphere are much reduced [85]).

4.4. Mulching

Mulching is the method of covering the surface of the soil with any decomposable material (grass, hay, leaves, waste etc.) Benefits include the soil is not dried by wind and sun exposure, moisture is reserved and soil erosion is prevented, rich humus is provided to the soil, and soil drainage is improved. It also leads to an increase in soil micro organisms and reduction in weed growth.

4.5. Composting

Composting is a process where microorganisms decompose organic matter to produce a humus-like substance called compost. The process is natural, provided the right organisms, water, oxygen, organic material, and nutrients are in place. By controlling these factors, the composting process can occur at a much faster rate [86]. The bacteria and fungi occurring in the soil convert dead organic matter present on its surface into a nutrient-rich medium. This is called composting, and the nutrient-rich medium is called compost. Following are the benefits of compost, compared to the usage of raw manure:

1. Making compost turns waste into a profitable resource.

2. Compost is environmentally friendly and promotes industry sustainability.

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3. Compost adds organic material, thereby improving the soil structure and water retention.
4. Compost use reduces the need for inorganic fertilizers.
5. Causes slow release of nutrients – nutrients are released to the plants slowly, thus reducing the loss of nutrients to the environment.

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