The Myth of Organic Agriculture

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Abstract

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Although many people are convinced of the superiority of organic agriculture in any form, there are many negative aspects that follow this type of agricultural system. The productivity of organic cropping systems is considerably lower than that of conventional or integrated systems and leads to less land being available for non-agricultural uses such as wildlife habitats, has greater negative impacts on the environment, and reduced sustainability. The absence of synthetic fertilisers or pesticides does not necessarily lead to an ability to produce healthy and safe food in an environmentally sustainable manner.

Keywords: organic agriculture; environment; yield; pesticides; fertilisers; food

In recent years we have witnessed the growth in popularity of organic farming and organic food worldwide, especially in Western Europe and North America, as a result of excess of food production and an increase in wealth (Trewavas 2004). Public perceptions, mainly based on non-scientific uncorroborated data, lead to the belief that organic agriculture as a farming system exists in harmony with nature, with lower inputs that are more friendly to the environment and more sustainable than conventional agriculture; crop yields from organic farms can be equal or superior to those from conventional farms (Soil Association). According to this perception, organic food is often viewed as healthier, benign and more nutritious because no synthetic fertilisers or pesticides have been used in its production, and therefore, that there are no pesticide residues present (Scialabba 1999).

Although these claims sound ideal, the reality is often quite different. Many professional researchers and scientists are convinced that these claims made about organic agriculture and food can not be scientifically supported. For consumers to make informed choices about the food they eat, it is essential that these claims are scientifically proven.

Taking into consideration all previous popular claims about organic agriculture and food, the aim of this review is to demystify the delusions and myths of organic agriculture and food through verified scientific arguments.

Philosophy of organic agriculture

Organic agriculture was developed from the philosophical views of Rudolf Steiner and later, Lady Eve Balfour (Trewavas 2001). This means that the concept of organic agriculture is based on ideology and not on science (Kirchmann & Thorvaldsson 2000). Above all, organic agriculture and its products are more myth and "New Age Religion" than science and reality (Scott & Sullivan 2000). The organic movement is governed by rules that have no basic scientific or agricultural foundation; it is steeped in mysticism, pseudo-science, logicality and confusion, particularly in certain areas of production (Leake 1999). This form of farming, with its belief in cosmic forces, has no place in any scientific discussion and is considered occult in character (Kirchmann 1994). The philosophical reasons for supporting organic farming are part of the "back-to-nature" syndrome. Like alternative medicine, they are based on the belief that "nature knows best" and that what is natural must be good. It is the nostalgia for a mythical 'golden age' of small-scale and simple farming, producing pure and wholesome farm products (Taverne 2005). Such a paradise never existed. In the days before intensive farming, when farmers did not use pesticides or artificial fertilisers, food supplies were constantly endangered through climatic and environmental fluctuations, and crops were frequently lost to pests and diseases. It was routine for farmers to lose 50–75% of their crops (Gianessi 2005). This period can be defined as the age of "fatigue". The English philosopher Thomas Hobbes described agriculture as grinding poverty, intensive labour, and low yield. The majority of the working population, approximately 90%, devoted their time to agricultural activities on small farms that scarcely produced enough to survive (Dinelli & Benvenuti 2003). Thanks to science for the chemicals that control the ever threatening attacks of weeds and pests, these ages are in the past. There is no going back to the good, old, pre-chemical days, no matter how much vociferous organic supporters, growers, and consumers might wish otherwise (Gianessi & Reigner 2006).

Harmony between nature and organic agriculture

Another fallacy. The truth is that there has never been a time or place on earth where there was harmony between agriculture, including organic agriculture, and nature. Nature has a cruel side with just one rule-survival of the fittest (Gianessi 2005). Man is governed by the survival instinct to change and adapt nature according his needs. As a result of intensive activities, man has created a new plant phytocenosis – antropophytocenosis. The formation and maintenance of antropophytocenosis is the result of systematic and dynamic activities of man, including the introduction and care of new edificator-cultivated varieties (Kojic & Sinzar 1985). Removal of weeds, control of pests, growth of crop monocultures, crop rotation, and the manipulation of soil fertility are unique and non-ecological contributions by the farmer. This means that antropophytocenosis is a land management system, not an ecosystem (Trewavas 2001). Cultivated varieties or crops, *per se*, are not competitive and rapidly disappear from the field without man's care (Nuffield 1999). For thousands of species of insects, fungi and bacteria, crops are ideal food sources. Land that is intended for cultivated varieties is heavily populated with millions of weed seeds without any nutritious value. If not removed, these useless weeds steal the light, space and nutrients that crops need to prosper (King 1966; Coble & Ritter 1978; Coble *et al*. 1981; Jordan *et al.* 1987). For thousands of years, millions of people spent their lives controlling weeds by hand or with primitive tools. As Leonard Gianessi said: "It was not harmonious – it was killing on a mass scale". In the 1840s in Ireland, several million people died or migrated because their potato fields were destroyed by a fungus – *Phytophthora infestans*". High birth rates and summer vacations for children were tightly connected with laborious activities in agriculture. Today, in the industrialised world, where the use of pesticides and fertilisers is high and intensive, only 2% of the population is involved in agricultural production (Stephenson 2000). In underdeveloped countries, this situation is still very bad, where up to 46% of the population is involved in field works, mainly weed control. In Brazil this is 20%, in Mexico 25%, in Kenya 70% or two people in every three (Akobundu 2000). The mass use of chemicals is freeing millions of people from a life of drudgery. The period of intensive chemical fertiliser and pesticide use that resulted in high levels of production is known as the agricultural revolution (Dinelli & Benvenuti 2003). Fortunately, this is ongoing.

Environment and organic agriculture

It is a common assumption that organic agriculture is environmentally superior to conventional or integrated agriculture, because it does not use synthetic pesticides and fertilisers (Trewavas 2004). It is argued that biodiversity is promoted and higher levels of plants, insects and birds are found and soil health is improved.

In reality, every kind of agriculture has an impact on the environment. The perception that organic farming is, *per se*, better for the environment because it relies on natural processes does not hold true. Natural processes are variable and outside the grower's control (Kidd & Lewis 1999). This can cause problems. Natural breakdown of mineral nitrogen, for example, can occur at the wrong time for the plants – mineral release is not synchronised with crop growth, increasing the chance of nitrate leaching (Myers *et al*. 1997). In Holland, Germany (Kirchmann & Thorvaldsson 2000) and the UK (Smil 2000), excessive manure breakdown has led to eutrophication of lakes and rivers; the volatile ammonia from fresh manure has damaged woodland (Hogstad *et al.* 1997; Bergstrom & Kirchmann 1999). In Korea and Japan the overuse of organic fertilisers by some organic farmers has caused some severe problems since they apply too much to satisfy the need of crops (Sohn 1996). Also, trace element accumulation is higher in organic soil particularly of cadmium, a known carcinogen (Anonymous 1999; Kirchmann & Thorvaldsson 2000). Inorganic fertilisers are now cleaned of cadmium whereas crude rock phosphate containing variable amounts of cadmium (Kirchmann & Thorvaldsson 2000) as used by organic farmers, gives cause for concern over further heavy metal accumulation (Witter 1996). Moreover, with organic farming, most weed control is done by mechanical cultivation methods, which exacerbates agricultural problems of soil compaction or soil erosion (Mackerron *et al.* 1999). Consequently fossil fuel consumption can be doubled, producing more global-warming carbon dioxide and damaging N oxides (Bertilsson 1992). Also, mechanical cultivation disrupts the soil structure, increases mineralisation (breakdown) of soil organic matter, removes valuable moisture, damages bird nestings and earthworms, and increases soil erosion (Trewavas 2001). Compared to efficient conventional farming conducted with good agricultural practices, organic farming has "no positive environmental aspects at all" (Bertilsson 1992). Namely, the use of herbicides in conventional or integrated agriculture has enabled "no-till" practices, which reduce disruption of the soil, reduce total fossil-fuel use and carbon dioxide production (Bertilsson 1992) and minimises soil erosion. The structure of the soil in no-till fields becomes more conducive to crop production, increasing soil porosity and water holding capacity (Clapperton *et al.* 1995). In addition, integrated farming methods can produce more food from less land than an organic system hence land can be taken out of cultivation and used to encourage wildlife (Holland *et al.* 1994). Managing inputs for profitable high-yield production minimises losses of nutrients that could potentially adversely affect the quality of the surface waters that surround cropland and the groundwater below it (Bruulsema 2002). Several researchers have acknowledged that any positive environmental impacts of organic farming systems are as yet unproven and require more research (Condron & Cameron 2000; Hansen & Alroe 2001). While risk per unit area of farm may be lower when practised as a small percentage of agricultural land, the overall environmental risks of organic production may increase dramatically as organic farming expands (Bruulsema 2002).

Sustainability of organic agriculture

Since crop production depends on many sources of inputs of a diverse nature (land, water, nutrients, genetic resources, labour, energy, technology, etc.) the definition of sustainable productivity depends on the particular input efficiency under consideration, and on interactions among inputs. In agriculture, both in the short as well as the long term, yield per unit area of land is the most critical component of sustainable productivity. Yield per unit area of land is important not only economically, but also for environmental, ecological and social reasons. For agriculture to be ecologically, socially and economically viable, it is more favourable to increase productivity on existing land rather than to expand cultivation into marginal areas or fragile ecosystems (IAFN 2000). A negative example of inefficient organic agriculture is that of Mexican peasants who destroy 3 million acres of virgin tropic forest/year in slash-and-burn agricultural practice (Gregory *et al.* 2002).

Crops produced organically will not always yield less, but very often do. Organic production has greater restrictions on inputs, because organic standards minimise or eliminate the use of synthetic or manufactured inputs and encourage maximum use of local natural resources. With these restrictions, it is more difficult to maintain high yield levels sustainably (Bruulsema 2002). A conventional farm can match organic yields using only 50–70% of the farmland (Trewavas 2001). In Europe, according to Zanoly (1999), the relative yield in organic systems compared to conventional ones averaged 68% for cereals and 73% for potatoes. However, for individual countries, these figures can range from 55–78% and 45–100%, respectively. If the organic rotation contains fallow years or years in which a crop with limited marketable value is included, specific crop yields can be very misleading. Comparisons must be based on yield of marketable product per unit area per unit time. For example, a 21-year study in Switzerland found that yields were 20% less when a rotation including wheat, potato and forage was grown organically (Mäder *et al.* 2002). However, the economically most important crop, potato, suffered the greatest yield reduction (38%).

Pesticides and organic agriculture

Chemophobia, the unreasonable fear of chemicals, is a common public reaction to scientific or media reports suggesting that exposure to various environmental contaminants may pose a threat to health (Safe 1997). Modern farm chemicals are not entirely without risk, but the hazards they pose to people and wildlife are near zero and declining (Avery 2002). It is important to address the common misperception that organic agriculture is "pesticide-free" (Avery 2006). The fundamental difference between pesticides used in organic and conventional agriculture is not their toxicity, but their origin. Pesticides used in organic agriculture are extracted from plants, insects or mineral ores and not by chemical synthesis. In fact, according data from the National Centre for Food and Agriculture Policy (NCFAP), two of the most popular organic-approved pesticides, oil and sulphur, are used more than any other pesticide, by volume, in the USA (NCFAP 2001). Although organic pesticides tend to be based on "natural" products this does not mean they are safer than the highly regulated and tested synthetic pesticides (Anonymous 2001). In particular, organic pesticides are used more intensively per hectare than non-organic pesticides because of lower effectiveness compared with their synthetic counterparts. Fungicides effectively illustrate this. The primary organic fungicides are sulphur and copper. Both products are mined from natural mineral ores. Both are toxic to a broad range of organisms and are long-term soil and environmental contaminants. Both are applied at significantly higher rates of active ingredient than synthetic fungicides (Avery 2006).

Table 1 makes some limited comparisons between mancozeb, a synthetic copper fungicide usually used to treat late blight, and the organic pesticide equivalent, copper sulphate (Leake 1999). In terms of environmental impact, mancozeb is superior in all categories compared to copper sulphate (Kovach *et al.* 1992). In terms of human health, copper sulphate is corrosive and toxic because it contains lead, and has caused liver disease in European vineyard workers (Trewavas 1999a, b). Although the EC theoretically banned copper sulphate in 2002, no alternative has been found for organic farmers and thus it continues to be used. The consequences of not using copper sulphate properly have been seen as organic farms acting as repositories of late blight a serious disease of potato (Eltun 1996; Zwankhuizein *et al.* 1998) or seriously damaged orchards (Van Embden & Peakall 1996).

Table 1. A comparison of human and ecotoxicity of mancozeb and copper sulphate

	Mancozeb	Copper
Human health		
LD_{50}	> 5000 mg/kg	50 mg/kg
EPA class	practically non-toxic	corrosive and toxic
Health effects	non-toxic by oral route	kidney and liver damage
Ecotoxicity		
Earthworms	low toxicity	very toxic
Birds	low	moderately toxic
Small mammals	non-toxic	harmful
DT_{50} soil	6–15 days	non-degradable

A similar situation occurs with organic insecticides which are used to kill insects on organic farms. According to the Environmental Impact Quotient (EIQ), some organic insecticides have a higher EIQ than some synthetics, notably Carbaryl (Sevin), one of the most commonly used synthetic pesticides in the world (Table 2).

Most of these have a negative impact on human health, as well. Rotenone has been recently shown to cause anatomical, neurochemical, behavioural and neuropathological symptoms of Parkinson's disease (Betarbet *et al.* 2000), *Bacillus thur-*

Table 2. EIQs of some insecticides

Insecticides	EIQ
Acephate (synthetic)	17.9
Soap (organic)	19.5
Carbaryl (synthetic)	22.6
Malathion (synthetic)	23.2
Rotenone (organic)	33.0
Sabadilla (organic)	35.6

inginensis spores, used to kill insects, can cause fatal lung infections in mice (MacKenzie 1999) and death from toxic shock in mammals (Kidd & Lewis 1999). Pyrethrum, another natural insecticide (the Environmental Protection Agency has described it as a common human carcinogen) is also used; the more effective synthetic pyrethroids that are used at much lower concentration and are equally degradable, are banned. The only category of chemical whose use would decrease under an all-organic scenario is that of herbicides (Avery 2006). But this decline in herbicide use would be accompanied by lower crop yields and higher soil erosion. The irony is that herbicides are the least toxic class of chemical and offer the most environmental benefits, as previously mentioned. Herbicides are predominantly compounds that narrowly target plant enzymes and are virtually harmless to insects and mammals. Yet the benefits from their use are enormous. An all-organic mandate would eliminate all of these benefits.

Plant protection in organic agriculture with “natural” and “safe” pesticides means more pesticide use, not less; more toxicity, not less; and higher pressures on agricultural and other natural resources without any apparent offsetting benefits.

Fertilisers and organic agriculture

Soluble mineral fertilisers are not used on organic farms. The main alternative mineral sources for crop nutrients are organic fertiliser (animal and green manure) (Trewavas 2001), $CaCO_3$ (chalk), KCl (sylvanite), $MgSO_4$ (kaiserite), rock phosphate, trace elements and eight other non-renewable inorganic chemicals, all for a claimed chemical-free agriculture (Trewavas 2004). Organic fertilisers can be a source of essential nutrients for plants as well as for the improvement of soil productivity. Although organic manures can supply all the essential plant nutrients, the full requirements for certain nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and sulphur, which are required in relatively larger amounts for normal crop growth and high yields, cannot be supplied through organic manures alone (Kumaraswamy 2003); the levels of essential plant nutrients contained in organic materials, including commercial organic fertilisers, are very low (Mamaril 2004). Eghball and Power (1990) provide detailed analyses of different manures indicating that all the major (N, P, K) and some of the minor minerals can vary 10-30-fold in different manures. Also, Eghball *et al.* (1997) found 20% to 40% loss of total N and 46% to 62% loss of total C during composting of beef cattle feedlot manure, as well as significant losses of K and Na (> 6.5% of total K and Na) in runoff from composting winrows during rainfall. Consequently, minerals from manure breakdown have not been observed to produce crops with superior qualities as organic farmers assert (Hansen 1980; Evers 1988; Conklin & Thompson 1993). Contrary to this, insufficient supply of these nutrients will lead to malnutrition of the crops, resulting in low yields and poor quality of the produce.

As well as low yield and poor quality, improper manure composting can lead to serious public health risks. For example, in the US, over 100 million tons of manure are produced per year and less than 7% is composted (Nelson 1997). The use of farmyard manure as a fertiliser gives rise to concerns about the possible contamination of agricultural produce with pathogens (especially *E. coli* 0157) and the possible contamination of ground and surface water. The UK Royal Commission on Environmental Pollution, in its 19th report on the Sustainable Use of Soil (1996), reviewed the use of organic materials in agriculture, including their safety. It concluded that there is a potential risk to human and animal health from pathogens in animal wastes (Kidd & Lewis 1999). A study at the University of Illinois has shown that consumers eating organic produce are eight times more likely to contract *E. coli* than those who eat conventional produce (Avery 2002). Animal manure is the biggest reservoir of these pathogenic bacteria that can afflict and kill so many people. Child death from eating organic parsley has been reported in the medical literature (Tschape *et al*. 1995). The

Centres for Disease Control (CDC) recorded 2471 confirmed cases of *E. coli* 0157: H7 in 1996 and estimated that it is causing at least 250 deaths per year in the United States alone (Avery 2002).

A conventional farmer can use manure just as a soil conditioner and provider of organic material to improve soil crumb structure. Such farmers are therefore not under the same pressure as an organic farmer who needs to apply manure quickly to the soil before much of the N disappears into the atmosphere as ammonia and probably nitrous oxide (Kirchmann & Thorvaldsson 2000). After 50 years and billions of dollars in research, scientists are still looking for the first victim of pesticide residues, whereas the new *E. coli* strain attacked thousands of people every year. This means that health risks are considered to be higher from food borne pathogens than pesticide residues (IFST 2003).

Organic food is safe?

There is no conclusive evidence that organically produced food is safer than that produced conventionally (Leake 1999). However, there have been particular aspects of organic farming and food that have raised concerns over safety. Namely, recent work shows that organic farms can act as reservoirs of disease (Eltun 1996; Zwankhuizen *et al.* 1998). A consequence of disease problems is the reported higher contamination of organic food by the mycotoxins, patulin (Lovejoy 1994) and fumonisin (Eltun 1996; Schollenberger *et al.* 1999). Plants react vigorously when attacked by disease organisms and synthesise many chemicals that are carcinogenic. Thus, organic cider from apples has much higher patulin levels, and celery has higher levels of psoralen which, without careful harvesting, can cause serious skin burns (Trewavas 1999a). The U.S. Food and Drug Administration (FDA) regularly tests samples of various foods for such dangers, and it routinely finds high levels of these natural toxins in organically grown produce. It found, for instance, that organic crops have higher rates of infestation by aflatoxin (made by the fungus *Aspergillus*), one of the most virulent carcinogens know to man (Trewavas 1999b). The organic-food sector stresses the "natural" production of foods and beverages, even to the point of refusing to pasteurise milk and fruit juices. As a result, many people become seriously ill after consuming products they mistakenly believe are safer than other foods (Avery 2002).

Organic food is more nutritious?

Organic food is certainly not more nutritious. Experiments conducted for many years have found no superiority in the nutrient content of organically grown crops compared to those grown under standard agricultural conditions (Newsome 1990; Woese *et al*. 1997; Bourn & Prescott 2002; Barrett 2006). Summaries from nutritionists and others indicate that occasionally there may be slight increases in vitamin C in potatoes, oranges and leafy vegetables probably due to a lower water content, so the vitamin C has been concentrated. In addition, vitamin C may accumulate when oxidative stress is experienced, a consequence of disease and perhaps of other deficiencies. A study of marionberry, strawberry and corn revealed that the organically farmed produce had higher levels of phenolics than conventionally grown versions. It is well known that plants produce phenolics in response to insect attack, as nature's insecticides (Asami *et al*. 2003). From approximately 150 studies, data show that organic products contain slightly lower nitrate levels and have a lower protein content (Schupan 1974). A three year Swedish field study by Pettersson (1977) found significantly higher crude protein concentrations (% dry matter) in conventionally grown potatoes, spring wheat and barley. Protein, important for building living tissue, is increased in corn, by nitrogen fertilisers. Ralph W. Cummings a director of research at North Carolina State College, said: "In a large number of experiments, the protein content was increased approximately 3%, that is, where the organic corn had only 5.7% protein, the fertilised averaged 10.4% protein." "It is considered that such higher-protein corn is superior feed-stuff." The results for maize, reported by Lockeretz *et al.* (1981) and by Wolfson and Shearer (1981), showed that the crude protein concentration in a conventionally grown crop was significantly higher than that in the organically grown crop. One study has actually shown processed organic products to be less healthy than their conventionally produced equivalents. A Sunday Times study has revealed that, compared with ordinary products, many processed organic foods contained higher levels of fat, sugar and salt, all of which can cause heart disease (Bevan 1999). Finely, and most importantly, the UK Advertising Standards Authority recently struck down such claims of superiority for organically grown food (McCarthy 2000).

Final remarks

Organic agriculture is politically favoured. The Green lobby self-righteously protects organic producers because it urgently wants the public to perceive organic farming as an environmentally benign alternative to the use of pesticides and chemical fertilisers (Avery 2002). However exclusive organic farming without using fertilisers and agricultural chemicals would be possible only under natural ecosystems like forestry but not under the highly productive intensive agriculture of field crops (Kumaraswamy 2003). Widespread organic farming is simply not a viable option at this time. The first consequence of a global shift to organic farming would be the ploughing of at least six-million square miles of wildlife habitat to make up for the lower yields of organic production. Synthetic pesticides have been used for 50 years. Average cancer rates have dropped by 15% and over 50% for stomach cancer from 1950 onwards (Coggon & Inskip 1994; Devesa *et al*. 1995). We live much longer and healthier thanks to cheap, conventional food; people are commonly living over 80–90 years (Doll & Peto 1981). Reductions in synthetic pesticide use will not effectively prevent diet-related cancer. Fruits and vegetables are of major importance for reducing cancer; if they become more expensive due to reduced use of synthetic pesticides, cancer is likely to increase. People with low incomes eat fewer fruits and vegetables and spend a higher percentage of their income on food (Ames & Gold 2000). Organic farming may satisfy the whim of the rich European or American consumer; but its extension to the developing world would be a disaster. Many countries in the world practice organic farming now; however not by choice, but from poverty. As the Indian biotechnologist, C.S. Prakash, has correctly observed: "The only thing sustainable about organic farming in the developing world is that it sustains poverty and malnutrition" (Taverne 2005).

If the world population peaks at 9 billion in 2050 (Berca 2004) and declines to about 5 billion in 2125, future generations may have the choice between wide scale dependence on organic farming or reducing the amount of land devoted to agriculture. It would be selfish, narrow minded and short sighted to think that we have those choices today (Stephenson 2000).

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