Methods[edit]


Organic cultivation of mixed vegetables in Capay, California

"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. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved..."

—*International Federation of Organic Agriculture Movements*[43]

Organic farming methods combine scientific knowledge of ecology and some modern technology with traditional farming practices based on naturally occurring biological processes. Organic farming methods are studied in the field of agroecology. While conventional agriculture uses synthetic pesticides and water-soluble synthetically purified fertilizers, organic farmers are restricted by regulations to using natural pesticides and fertilizers. An example of a natural pesticide is pyrethrin, which is found naturally in the Chrysanthemum flower. The principal methods of organic farming include crop rotation, green manures and compost, biological pest control, and mechanical cultivation. These measures use the natural environment to enhance agricultural productivity: legumes are planted to fix nitrogen into the soil, natural insect predators are encouraged, crops are rotated to confuse pests and renew soil, and natural materials such as potassium bicarbonate[44] and mulches are used to control disease and weeds. Genetically modified seeds and animals are excluded.

While organic is fundamentally different from conventional because of the use of carbon-based fertilizers compared with highly soluble synthetic based fertilizers and biological pest control instead of synthetic pesticides, organic farming and large-scale conventional farming are not entirely mutually exclusive. Many of the methods developed for organic agriculture have been borrowed by more conventional agriculture. For example, Integrated Pest Management is a multifaceted strategy that uses various organic methods of pest control whenever possible, but in conventional farming could include synthetic pesticides only as a last resort.[45] Examples of beneficial insects that are used in organic farming include, ladybugs, lacewings which they both which feed on aphids. The use of IPM lowers the possibility of pest developing resistance to pesticides that are applied to crops.

Crop diversity[edit]

Organic farming encourages crop diversity. The science of Agroecology has revealed the benefits of polyculture (multiple crops in the same space), which is often employed in organic farming.[46] Planting a variety of vegetable crops supports a wider range of beneficial insects, soil microorganisms, and other factors that add up to overall farm health. Crop diversity helps the environment to thrive and protects species from going extinct.[47]

Soil management[edit]

Placard advocating organic food rather than global warming

Organic farming relies more heavily on the natural breakdown of organic matter than the average conventional farm, using techniques like green manure and composting, to replace nutrients taken from the soil by previous crops. This biological process, driven by microorganisms such as mycorrhiza and earthworms, releases nutrients available to plants throughout the growing season. Farmers use a variety of methods to improve soil fertility, including crop rotation, cover cropping, reduced tillage, and application of compost. By reducing fuel-intensive tillage, less soil organic matter is lost to the atmosphere. This has an added benefit of carbon sequestration, which reduces greenhouse gases and helps reverse climate change. Reducing tillage may also improve soil structure and reduce the potential for soil erosion.

Plants need a large number of nutrients in various quantities to flourish. Supplying enough nitrogen and particularly synchronization, so that plants get enough nitrogen at the time when they need it most, is a challenge for organic farmers.[48] Crop rotation and green manure ("cover crops") help to provide nitrogen through legumes (more precisely, the family Fabaceae), which fix nitrogen from the atmosphere through symbiosis with rhizobial bacteria. Intercropping, which is sometimes used for insect and disease control, can also increase soil nutrients, but the competition between the legume and the crop can be problematic and wider spacing between crop rows is required. Crop residues can be ploughed back into the soil, and different plants leave different amounts of nitrogen, potentially aiding synchronization.[48] Organic farmers also use animal manure, certain processed fertilizers such as seed meal and various mineral powders such as rock phosphate and green sand, a naturally occurring form of potash that provides potassium. In some cases pH may need to be amended. Natural pH amendments include lime and sulfur, but in the U.S. some compounds such as iron sulfate, aluminum sulfate, magnesium sulfate, and soluble boron products are allowed in organic farming.[49]:43

Mixed farms with both livestock and crops can operate as ley farms, whereby the land gathers fertility through growing nitrogen-fixing forage grasses such as white clover or alfalfa and grows cash crops or cereals when fertility is established. Farms without livestock ("stockless") may find it more difficult to maintain soil fertility, and may rely more on external inputs such as imported manure as well as grain legumes and green manures, although grain legumes may fix limited nitrogen because they are harvested. Horticultural farms that grow fruits and vegetables in protected conditions often rely even more on external inputs.[48] Manure is very bulky and is often not cost-effective to transport more than a short distance from the source. Manure for organic farms' may become scarce if a sizable number of farms become organically managed.

Weed management[edit]

Organic weed management promotes weed suppression, rather than weed elimination, by enhancing crop competition and phytotoxic effects on weeds.[50] Organic farmers integrate cultural, biological, mechanical, physical and chemical tactics to manage weeds without synthetic herbicides.

Organic standards require rotation of annual crops,[51] meaning that a single crop cannot be grown in the same location without a different, intervening crop. Organic crop rotations frequently include weed-suppressive cover crops and crops with dissimilar life cycles to discourage weeds associated with a particular crop.[50] Research is ongoing to develop organic methods to promote the growth of natural microorganisms that suppress the growth or germination of common weeds.[52]

Other cultural practices used to enhance crop competitiveness and reduce weed pressure include selection of competitive crop varieties, high-density planting, tight row spacing, and late planting into warm soil to encourage rapid crop germination.[50]

Mechanical and physical weed control practices used on organic farms can be broadly grouped as:[53]

- Tillage - Turning the soil between crops to incorporate crop residues and soil amendments; remove existing weed growth and prepare a seedbed for planting; turning soil after seeding to kill weeds, including cultivation of row crops.
- Mowing and cutting - Removing top growth of weeds.
- Flame weeding and thermal weeding - Using heat to kill weeds.
- Mulching - Blocking weed emergence with organic materials, plastic films, or landscape fabric.[54]

Some naturally sourced chemicals are allowed for herbicidal use. These include certain formulations of acetic acid (concentrated vinegar), corn gluten meal, and essential oils. A few selective bioherbicides based on fungal pathogens have also been developed. At this time, however, organic herbicides and bioherbicides play a minor role in the organic weed control toolbox.[53]

Weeds can be controlled by grazing. For example, geese have been used successfully to weed a range of organic crops including cotton, strawberries, tobacco, and corn,[55] reviving the practice of keeping cotton patch geese, common in the southern U.S. before the 1950s. Similarly, some rice farmers introduce ducks and fish to wet paddy fields to eat both weeds and insects.[56]

Controlling other organisms[edit]

Chloroxylon is used for pest management in organic rice cultivation in Chhattisgarh, India.

See also: Biological pest control and Integrated Pest Management

Organisms aside from weeds that cause problems on farms include arthropods (e.g., insects, mites), nematodes, fungi and bacteria. Practices include, but are not limited to:

Examples of predatory beneficial insects include minute pirate bugs, big-eyed bugs, and to a lesser extent ladybugs (which tend to fly away), all of which eat a wide range of

pests. Lacewings are also effective, but tend to fly away. Praying mantis tend to move more slowly and eat less heavily. Parasitoid wasps tend to be effective for their selected prey, but like all small insects can be less effective outdoors because the wind controls their movement. Predatory mites are effective for controlling other mites.[49]:66–90

Naturally derived insecticides allowed for use on organic farms include *Bacillus thuringiensis* (a bacterial toxin), pyrethrum (a chrysanthemum extract), spinosad (a bacterial metabolite), neem (a tree extract) and rotenone (a legume root extract). Fewer than 10% of organic farmers use these pesticides regularly; a 2003 survey found that only 5.3% of vegetable growers in California use rotenone while 1.7% use pyrethrum.[57]:26 These pesticides are not always more safe or environmentally friendly than synthetic pesticides and can cause harm.[49]:92 The main criterion for organic pesticides is that they are naturally derived, and some naturally derived substances have been controversial. Controversial natural pesticides include rotenone, copper, nicotine sulfate, and pyrethrums[58][59] Rotenone and pyrethrum are particularly controversial because they work by attacking the nervous system, like most conventional insecticides. Rotenone is extremely toxic to fish[60] and can induce symptoms resembling Parkinson's disease in mammals.[61][62] Although pyrethrum (natural pyrethrins) is more effective against insects when used with piperonyl butoxide (which retards degradation of the pyrethrins),[63] organic standards generally do not permit use of the latter substance.[64][65][66]

Naturally derived fungicides allowed for use on organic farms include the bacteria *Bacillus subtilis* and *Bacillus pumilus*; and the fungus *Trichoderma harzianum*. These are mainly effective for diseases affecting roots. Compost tea contains a mix of beneficial microbes, which may attack or out-compete certain plant pathogens,[67] but variability among formulations and preparation methods may contribute to inconsistent results or even dangerous growth of toxic microbes in compost teas.[68]

Some naturally derived pesticides are not allowed for use on organic farms. These include nicotine sulfate, arsenic, and strychnine.[69]

Synthetic pesticides allowed for use on organic farms include insecticidal soaps and horticultural oils for insect management; and Bordeaux mixture, copper hydroxide and sodium bicarbonate for managing fungi.[69] Copper sulfate and Bordeaux mixture (copper sulfate plus lime), approved for organic use in various jurisdictions,[64][65][69] can be more environmentally problematic than some synthetic fungicides disallowed in organic farming.[70][71] Similar concerns apply to copper hydroxide. Repeated application of copper sulfate or copper hydroxide as a fungicide may eventually result in copper accumulation to toxic levels in soil,[72] and admonitions to avoid excessive accumulations of copper in soil appear in various organic standards and elsewhere. Environmental concerns for several kinds of biota arise at average rates of use of such substances for some crops.[73] In the European Union, where replacement of copper-based fungicides in organic agriculture is a policy priority,[74] research is seeking alternatives for organic production.[75]

Livestock[edit]

For livestock, like these healthy cows, vaccines play an important part in animal health since antibiotic therapy is prohibited in organic farming.

Raising livestock and poultry, for meat, dairy and eggs, is another traditional farming activity that complements growing. Organic farms attempt to provide animals with natural living conditions and feed. Organic certification verifies that livestock are raised according to the USDA organic

regulations throughout their lives.[76] These regulations include the requirement that all animal feed must be certified organic.

Organic livestock may be, and must be, treated with medicine when they are sick, but drugs cannot be used to promote growth, their feed must be organic, and they must be pastured.[77]:19ff[78]

Also, horses and cattle were once a basic farm feature that provided labour, for hauling and plowing, fertility, through recycling of manure, and fuel, in the form of food for farmers and other animals. While today, small growing operations often do not include livestock, domesticated animals are a desirable part of the organic farming equation, especially for true sustainability, the ability of a farm to function as a self-renewing unit.

Genetic modification[edit]

Main articles: Genetically modified crops, Genetically modified food, and Genetically modified food controversies

A key characteristic of organic farming is the exclusion of genetically engineered plants and animals. On 19 October 1998, participants at IFOAM's 12th Scientific Conference issued the Mar del Plata Declaration, where more than 600 delegates from over 60 countries voted unanimously to exclude the use of genetically modified organisms in organic food production and agriculture.

Although opposition to the use of any transgenic technologies in organic farming is strong, agricultural researchers Luis Herrera-Estrella and Ariel Alvarez-Morales continue to advocate integration of transgenic technologies into organic farming as the optimal means to sustainable agriculture, particularly in the developing world.[79] Organic farmer Raoul Adamchak and geneticist Pamela Ronald write that many agricultural applications of biotechnology are consistent with organic principles and have significantly advanced sustainable agriculture.[80]

Although GMOs are excluded from organic farming, there is concern that the pollen from genetically modified crops is increasingly penetrating organic and heirloom seed stocks, making it difficult, if not impossible, to keep these genomes from entering the organic food supply. Differing regulations among countries limits the availability of GMOs to certain countries, as described in the article on regulation of the release of genetic modified organisms.

Tools[edit]

Organic farmers use a number of traditional farm tools to do farming, and may make use of agricultural machinery in similar ways to conventional farming. In the developing world, on small organic farms, tools are normally constrained to hand tools and diesel powered water pumps.

Standards[edit]

Main article: Organic certification

Standards regulate production methods and in some cases final output for organic agriculture. Standards may be voluntary or legislated. As early as the 1970s private associations certified organic producers. In the 1980s, governments began to produce organic production guidelines. In the 1990s, a trend toward legislated standards began, most notably with the 1991 EU-Eco-regulation developed for European Union,[81] which set standards for 12 countries, and a 1993 UK program. The EU's program was followed by a Japanese program in 2001, and in 2002 the U.S. created the National Organic Program (NOP).[82] As of 2007 over 60 countries regulate organic farming (IFOAM 2007:11). In 2005 IFOAM created the Principles of Organic Agriculture, an international guideline for certification criteria.[83] Typically the agencies accredit certification groups rather than individual farms.

Production materials used for the creation of USDA Organic certified foods require the approval of a NOP accredited certifier.

EU-organic production-regulation on "organic" food labels define "organic" primarily in terms of whether "natural" or "artificial" substances were allowed as inputs in the food production process.[84]

Composting[edit]

Using manure as a fertilizer risks contaminating food with animal gut bacteria, including pathogenic strains of E. coli that have caused fatal poisoning from eating organic food.[85] To combat this risk, USDA organic standards require that manure must be sterilized through high temperature thermophilic composting. If raw animal manure is used, 120 days must pass before the crop is harvested if the final product comes into direct contact with the soil. For products that do not directly contact soil, 90 days must pass prior to harvest.[86]

In the US, the Organic Food Production Act of 1990 (OFPA,) as amended, specifies that a farm can not be certified as organic if the compost being used contains any synthetic ingredients. The OFPA singles out commercially blended fertilizers [composts] disallowing the use of any fertilizer [compost] that contains prohibited materials.