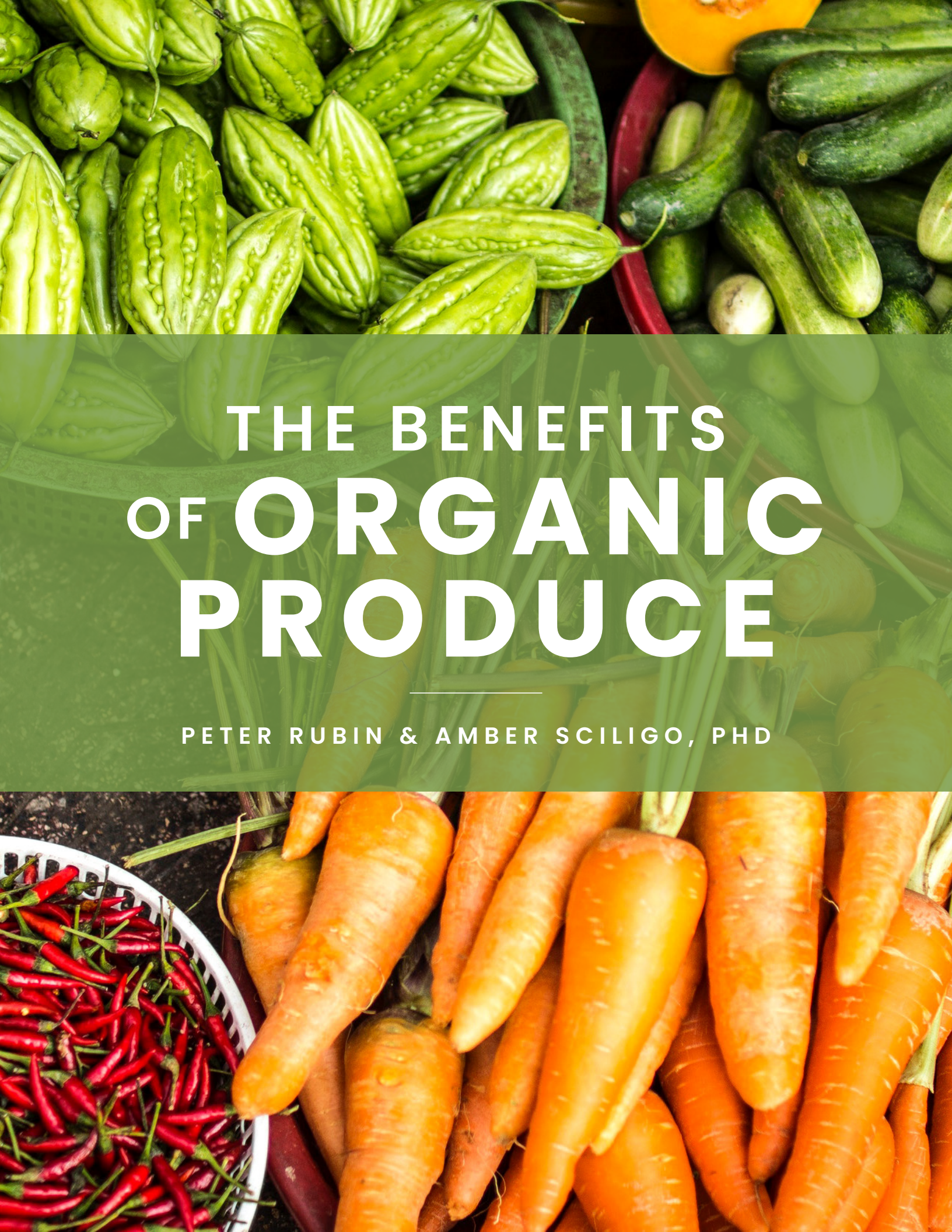

THE BENEFITS OF ORGANIC PRODUCE

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Contents

The benefits of organic produce

Organic produce is a better choice for consumers, farmers, and the environment. Produce is a critical component of a healthy diet. Whether eaten fresh or cooked, it provides essential vitamins, minerals, and antioxidants that boost our immunity and combat our daily exposure to environmental contaminants. However, non-organic produce is often grown with synthetic pesticides and fertilizers (common agrochemicals that can be harmful to human and environmental health).

Organic farmers are prohibited from using these toxic synthetic chemicals and instead, rely on natural ecosystem services to manage pests and provide the required nutrients for crop growth. This report gathers research from the U.S. and other countries showing how organic farming benefits the planet and improves the quality of the produce you eat.

Organic agriculture benefits human health, the planet, and the farmers and farmworkers who grow our food. While having a longer shelf-life, organic fruits and vegetables are also tastier and more nutritious than their conventional counterparts. Eating organic produce limits dietary exposure to pesticides, which can harm overall human health and development. Similarly, farming organically drastically improves the health of those growing our food by limiting chemical exposure from pesticide application. The higher premiums associated with organic products improve farmers' livelihoods providing an opportunity for all agricultural professionals to build their success by adding organic to their current cultivation methods. Organic farming not only helps ensure a sustainable supply of food production, but it also has much broader, positive impacts on the planet by producing fewer greenhouse gas emissions, preventing chemical contamination of air, water and soil, and boosting local biodiversity.

While having a longer shelf-life, **organic fruits and vegetables** are also tastier and more nutritious than their conventional counterparts.

What does organic mean for produce?

Produce is subject to organic standards that apply to farming (for fresh products), post-harvest handling (storage and packing), and processing (for products cooked or transformed into something other than the raw ingredient). Wherever crops are grown, organic farming practices must maintain or improve the natural resources on and around the farm and are prohibited from using toxic synthetic fertilizers and pesticides. Soil fertility must be managed with practices like crop rotation, cover cropping, application of biological soil amendments (non-synthetic fertilizer), and conservation tillage. Sewage sludge, which is known to contain harmful heavy metals, toxic chemicals, and microplastics is prohibited. Genetically modified seeds and plant materials are also prohibited.

Organic standards are proven to:

- Improve air and water quality
- Reduce human health risks
- Improve biodiversity and soil health
- Reduce energy consumption
- Reduce greenhouse gas emissions
- Increases resilience to extreme weather events

Organic standards have been scientifically demonstrated to improve biodiversity, soil health, and reduce human health risks, greenhouse gases, and energy consumption associated with the manufacturing of synthetic agrochemicals.

For various reasons, including the demand for many kinds of produce to be available all the time (instead of choosing only what is in season locally), much organic produce is grown and processed outside of the U.S. and imported. In this case, USDA organic standards and 3rd party certification apply to both domestic and imported organic products, and these standards are ensured either through USDA's National

Organic Program certification or organic equivalency agreements with the country of export. Like the U.S., many countries have their own organic standards and certification programs. Organic equivalence is a mutual recognition in the form of bilateral agreements that recognizes countries' standards as comparable without compromising the integrity of organic designation in both markets.

When organic produce is processed, the final product is not allowed to contain artificial flavors, colors, preservatives, or other synthetic chemicals. Minor non-organic ingredients used in organic food must be unavailable in organic form and come from a list of approved substances that have been evaluated for their safety and impact on both human and environmental health. By law, these ingredients may only make up 5% or less of the total ingredients (excluding water and salt) used to make the organic product and they must be produced without the use of genetic engineering (GMOs), ionizing radiation, or sewage sludge.

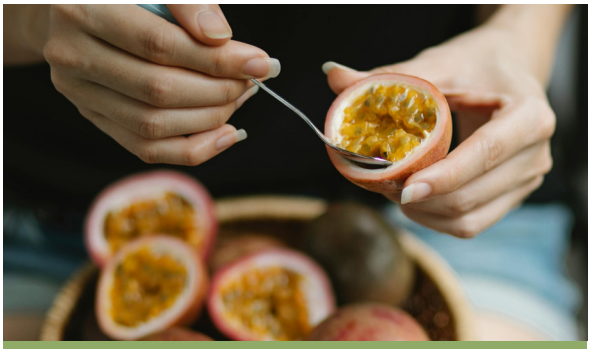
Organic processors must take several steps to ensure additional requirements are met. These include thoroughly cleaning machinery, processing, and storing organic ingredients and non-organic ingredients separately, and thorough record-keeping to verify that when you buy an organic product it contains only what you expect.

Visit ConsciousKitchen.org to learn more about in-season organic produce of the month.

Organic produce is healthier, tastier

Organic produce contains more antioxidants, nutrients

Fruits and vegetables are a key source of many nutrients, including antioxidants, minerals, and other micronutrients, and are critical to using food as medicine to ensure good health. Antioxidants are oxidation-inhibiting compounds, which can prevent disease and free radical formation that can lead to various cancers in humans. These naturally occurring compounds–used in the plant immune system–have higher concentrations in organic plants. For example, organic apples have higher levels of antioxidants, including flavonols and phenolic acids, raised by 66% and 31% respectively, compared to conventional apples. Organic passion fruits have higher vitamin C levels, due to higher plant immune system activity throughout their development. Under organic cultivation, oranges contain 10.7% more vitamin C in addition to 21.4% more essential oils.



Organic passion fruits have higher vitamin C levels, due to higher plant immune system activity throughout their development.

Organic produce tastes better, lasts longer

Compounds accrued during fruit development, like sugars and acids, contribute to the taste of the final product. Harsh chemical pesticides put stress on fruits like strawberries during development, affecting sugar synthesis. A study found that stress incurred by pesticide application encourages sugar breakdown and inhibits sugar transport into the fruit. It was noted that consumers prefer the taste of organic strawberries, which were sweeter.

Organic lemons were found to be preferred by 78% of consumers. A study identified organic lemons as having a higher concentration of aroma-inducing volatile compounds, with 20–38% more of the three most common of these compounds.

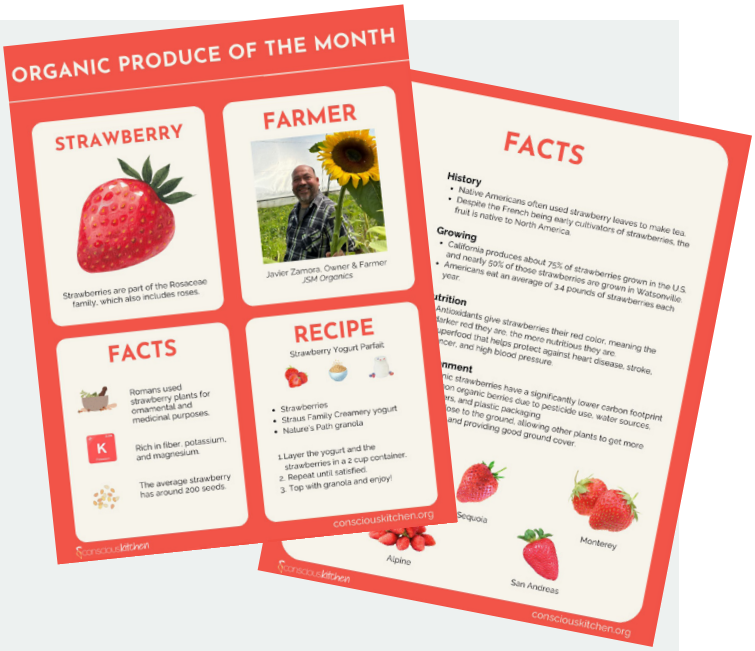
Similarly, organic lemons were found to be preferred by 78% of consumers. A study identified organic lemons as having a higher concentration of aroma-inducing volatile compounds, with 20–38% more of the three most common of these compounds. Consumers recognized the increased level of these compounds, identifying organic lemons as more aromatic—possibly leading to a preference in taste.

The higher antioxidant levels in organic fruits have the added benefit of increasing their shelf-life due to antioxidants' oxidation inhibiting effect, which slows the rate at which fruit ages after harvest. Organic products last for longer *naturally* before becoming overripe or spoiling, preserving quality produce taste for longer. Additionally, for organic produce like beans, this increase in shelf life translates to more important nutrients, beyond antioxidants, such as minerals (potassium, magnesium, sodium, calcium, iron, and zinc) and vitamin C.

Organic strawberries are tastier, more nutritious

A study comparing organic and conventional strawberries in taste-related indicators and nutrient concentration found organic fruits **to be both sweeter and healthier**. Organic strawberries hosted more antioxidants ascorbate and B-carotene, and significantly less nitrates than conventional plants.

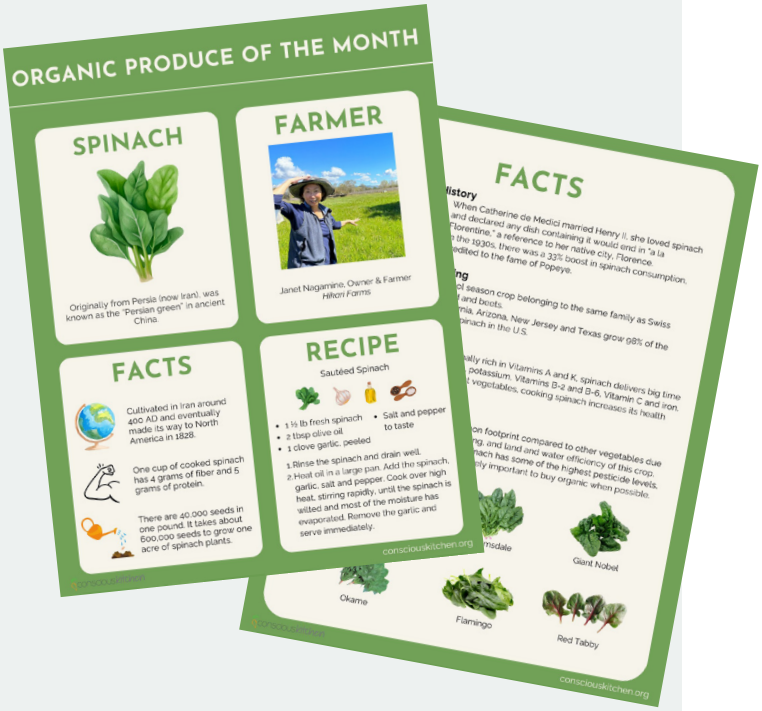
Visit ConsciousKitchen.org to learn more about organic strawberries.



Organic spinach has more vitamin C, fewer nitrates

A study analyzing the effect of agrochemical application on spinach found that refraining from the use of chemical fertilizer has a positive effect on nutritional contents. Compared to conventional spinach, the organic greens contained higher levels of vitamin C. Researchers found organic fertilizers to be effective in promoting spinach growth while ensuring nutrition of the leaves we eat.

Visit ConsciousKitchen.org to learn more about organic spinach.



For organic produce like beans, increase in shelf life translates to **more important nutrients**, beyond antioxidants, such as minerals (potassium, magnesium, sodium, calcium, iron, and zinc) and vitamin C.

Human health benefits of organic farming and produce

Organic reduces dietary exposure to pesticides

There have been several studies examining dietary exposure to pesticides. One study detected glyphosate, one of the most common pesticides used in conventional farming today, in human urine samples. The levels of glyphosate dropped by over 70% after switching to an organic diet for only one week. Another study detected 17 distinct pesticides, several of which have been correlated with negative health outcomes, including organophosphates, neonicotinoids, and pyrethroids, which all significantly dropped after only a few days of switching to an organic diet. Even in rural areas with high levels of airborne exposure, lower bodily concentrations of pesticides were found once children switched to an organic diet.

Non-organic produce can be laden with pesticides

Many studies that test conventional produce have detected pesticide residues on the surfaces and within the fruits and vegetables, themselves. Though there are techniques to remove large portions of these chemicals, these methods are imperfect and inconvenient to the average consumer and cannot remove systemic pesticides that are absorbed into plants. Organic crops are grown without toxic pesticides and provide the safest strategy to reduce exposure to these harsh chemicals.

Not all conventional producers follow the maximum residue guidelines established by their country's respective governments, which means that consumers of non-organic foods end up eating large quantities of pesticides and other chemicals that are allowed in conventional food production and processing. A recent meta-analysis of 24

Organic diets are of utmost importance in limiting risks associated with pesticide consumption for children. Pesticide exposure has a larger impact for children because their bodies are smaller and actively developing.

studies from 13 countries across the world (excluding the U.S.) examined the association of organophosphate residues with 77 varieties of fruits and vegetables. Positive samples existed in every study and some samples exceeded safe tolerance limits.

A French study aimed to assess consumer pesticide intake found that 37% of food samples–representative of a typical diet–contained pesticide residues. 19% contained more than one pesticide. In the diets of infants and young children, 67% of food samples contained pesticide residues with 56% containing more than one.

In the US, imported produce frequently violates federal pesticide limits. In 2021, FDA's Pesticide Residue Monitoring Program found 3.3% of domestic and 10.7% of imported human food samples to be contaminated with residues at levels that are non-compliant with the FDA limits. Some food categories were more contaminated than others, and fruits and vegetables had the highest violation rates. For imported produce, 10.3% of fruit samples and 11.8% of vegetable samples contained violative residues. Domestic produce fared better with 0% of fruit samples and 6.5% of vegetable samples containing violating residue limits. This monitoring program indicates that pesticide residues are hard to avoid, especially in non-organic diets.

Dietary intake of pesticides puts consumers at risk

Health risks associated with pesticide consumption come from two concentrations of exposure: acute and chronic, sub-lethal exposure. Acute exposure–associated with short-term overdoses of a given toxin–can cause symptoms as serious as seizures, loss of consciousness, and death. Barring serious allergic reactions, these risks are near-zero in typical food consumption.

Chronic, sub-lethal exposure, on the other hand, results in serious risk associated with regular low-dose exposure to pesticides. A French study, which analyzed pesticide residues in accordance with consumer diet surveys, found that consumers may be consuming levels above the acceptable daily intake

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of multiple pesticides, including dimethoate and carbofuran. These toxins were mostly accrued through the consumption of conventional vegetables and beverages.

For children, pesticide exposure has a larger impact because their bodies are smaller and actively developing. Organic diets are of utmost importance in limiting risks associated with pesticide consumption for children. Pesticide exposure can cause neurodevelopmental issues that impact cognitive function and because children weigh less than adults, it takes smaller doses for the effects of chronic exposure to occur. A French study that focused on the diets of infants and young children found pesticides lindane, dieldrin, and propylene to possibly exceed acceptable daily intake in these populations.

Eating organic produce during pregnancy helps mitigate the effects of chronic pesticide exposure during key developmental stages.

Eating organic produce during pregnancy is also helpful in mitigating the effects of chronic pesticide exposure during key developmental stages. Pregnant women who eat organic produce host significantly lower levels of pesticides.

As testing technology continues to advance, it will become easier to detect pesticides at lower concentrations. Currently, some tests are not sensitive enough to detect very low levels of pesticide residues, underestimating exposure. And while it's unclear how exposure to such low doses of pesticides and multiple pesticides that can interact affect our health, those who want to take a precautionary approach should choose organic produce grown without toxic chemicals.

Pesticide usage in non-organic produce

A wide variety of pesticides are used globally

While organic farmers support and rely more heavily on ecosystem services that protect their crops from pests and diseases, non-organic farmers are allowed to use a wide array of pesticides that range in toxicity, with some requiring 96 hours (4 days) between spraying and reentry to the field. Allowable conventional pesticides are separated into common classes according to their chemical formula and effects.

Systemic pesticides–
most often neonicotinoids–
are sprayed on the soil or used in seed coatings. The chemicals are absorbed through plant roots and travel throughout the plant's tissues. These chemicals are embedded within the plant and cannot be washed off the surface like non-systemic pesticides.

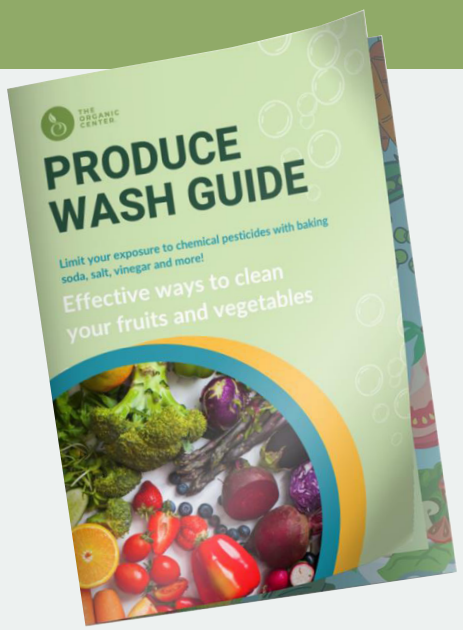
Broadly, these chemicals are grouped into organochlorines, organophosphates, pyrethroids, carbamates, and neonicotinoidsall of which are associated with negative health outcomes from acute and chronic exposure.

The United States is the second-largest user of pesticides in the world, behind China. Though pesticide application has risen by more than ten times since 1945, insect damage has doubled alongside it, indicating that increasing pesticide usage is not effective in long-term pest reduction. This overapplication of pesticides led to chemical residue detection in groundwater throughout the nation. While the federal government has banned certain harmful pesticides like DDT, it lags other nations, especially in Europe, in banning other chemicals proven to be harmful, like many organophosphates. With known neurotoxins for humans, organophosphate pesticides make up one of the most heavily used classes of pesticides in the United States, widely applied to conventional produce crops.

Europe contains the strictest pesticide legislation seen across the globe, setting stringent maximum residue limits in foods and being liberal with banning harmful substances. However, pesticides still remain a dominant pollutant, with a study in Germany finding them scattered throughout the entire country, even away from agricultural areas. In European cities herbicides are frequently sprayed, boosting the risk of airborne exposure for those who live outside of rural areas.

Though pesticides are typically sprayed onto fruits, flowers and leaves, they can also be systemic. Systemic pesticides–most often neonicotinoids–are absorbed through plant roots and travel throughout the plant's tissues. These chemicals are embedded

The ***Produce Wash Guide*** by The Organic Center offers science-backed washing strategies that help reduce the risk to non-systemic pesticides found in non-organic produce.



within the plant and spread through all plant tissues. They cannot be washed off the surface like non-systemic pesticides.

Certain fruits and vegetables are more contaminated with pesticides than others

Differences in farming practices, sprays used, surfaces textures of fruits and vegetables, and processing procedures, result in variability in pesticide residues left on the surface of produce. Each year the Environmental Working Group tests and reports the fruits and vegetables with the highest levels of contamination. While organic versions of the top contaminated fruits and vegetables are safer, healthier and more environmentally conscious, consumers with limited access to organic produce can keep these important fruits and veggies in their diets *and* lower their risk of exposure to pesticide residues by using effective washing strategies. The Produce Wash Guide by The Organic Center offers science-backed washing strategies that help reduce the risk to non-systemic pesticides found in non-organic produce.

Organic farming reduces occupational exposure to pesticides, improves farmer and community health

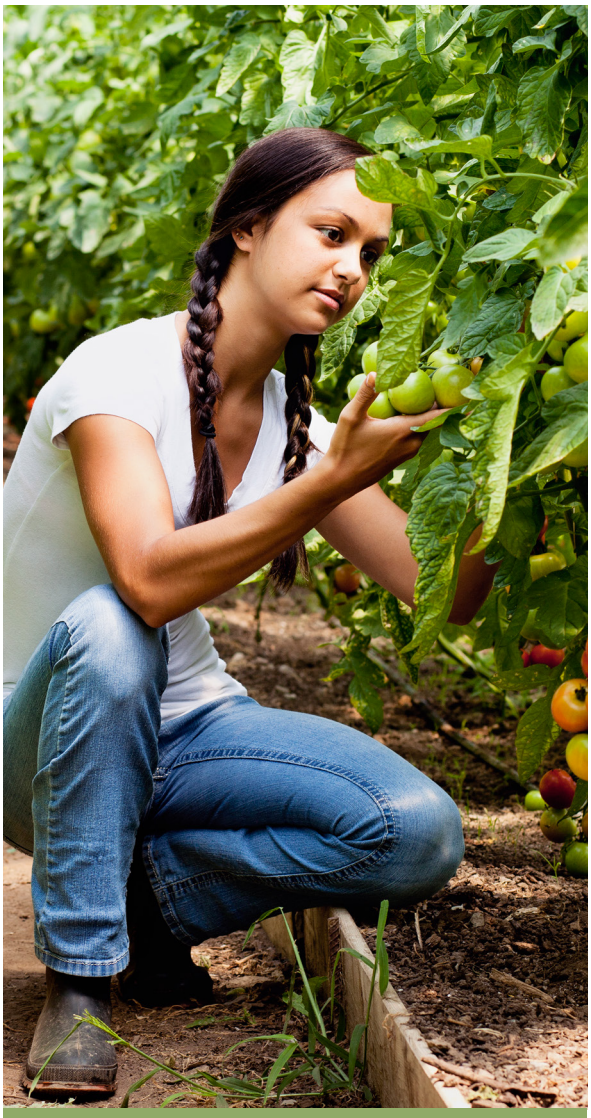
Airborne pesticide exposure poses threats to farmworkers who apply the chemicals, as well as the people surrounding the farms. Pesticides can be absorbed through the skin, respiratory system, and digestive system, leaving many pathways to exposure when these persistent pollutants are near. Organic farming practices that eliminate the use of these agrochemicals can reduce disease risks for farmers and local communities.

Organic farms maintain mental and physical health of local children

Children and fetuses are at the highest risk of the health effects of pesticide exposure. These harsh chemicals affect development and require lower doses to do so in children who are already lightweight. In Salinas–a California community known for its strawberry, lettuce, and tomato farms–multiple studies have been conducted by CHAMACOS to examine the effect of pesticide application on nearby pediatric health. They found that children exposed to pesticides are more likely to develop respiratory illnesses, including asthma. Additionally, CHAMACOS found an association between exposure to pesticides by pregnant women and attention deficiency in their children. Organic cultivation limits airborne exposure by children and pregnant women in farming communities, reducing developmental risks.

Organic farmers have lowered risk of chronic disease

Conversion to organic farming can drastically improve farmer health, as



Organic farming practices that eliminate the use of synthetic agrochemicals can reduce disease risks for farmers and local communities.

Organic helps protect children and fetuses, who are at the highest risk of the health effects of pesticide exposure.

occupational pesticide exposure—which can occur in high quantities—is eliminated. Even when using PPE, conventional farmers show clear signs of pesticide exposure. Studies have shown links between occupational pesticide use and chronic diseases like Parkinson's, Alzheimer's, and ALS. People who frequently apply these harsh chemicals have reproductive difficulties including higher miscarriage rates, lower sperm counts, and sex hormone disruption. Farmworkers who commonly apply pesticides have higher rates of asthma and COPD, and are more likely to develop chronic coughs.

Frequent pesticide exposure alters DNA

Frequent pesticide application even disrupts farmer DNA. In Brazil, a country rapidly increasing agrochemical usage, a study found that farmers show higher levels of DNA damage in Leukocytes compared to non-farmers. DNA mutations and damage are a common precursor to cancer, and these results corroborate the higher Leukemia rates in people exposed to organochlorine pesticides. A study found that North Carolina farmers display differences in DNA structure with more-methylated DNA, associated with tightly bound chromatin and low levels of gene transcription.

Organic farms benefit local communities

Abstention from pesticide application on organic farms eliminates pesticide drift incurred by local communities. From drift alone, local pesticide application can accelerate the development of chronic and neurotoxic diseases. A years-long observation of Parkinson's patients found faster progression of the disease in those who lived or worked near sites of pesticide application throughout their lifetime. 10 common agrochemicals were associated with this accelerated progression, leading to worsened motor, cognitive, and depressive symptoms.

Organic farming boosts ecosystem services, ensures steady production of healthy food

Ecosystem services are functions of nature that benefit humans and are often given a monetary value. These services include the regulation of clean air and water, the generation of food and raw materials (e.g. fiber for clothing and timber for building), nutrient cycling, and the creation of culturally significant and aesthetic sites. Many organic practices strengthen the mechanisms behind these services, benefiting all of society. Maintaining ecosystem services is also critical for organic farmers who rely upon these services instead of chemicals to manage pests and diseases and ensure high quality yields.

Though many ecosystem services are intrinsically valuable, many exhibit strong economic worth as well. In one study that quantified the value of services provided by both organic and conventional croplands, organic farmlands were more economically

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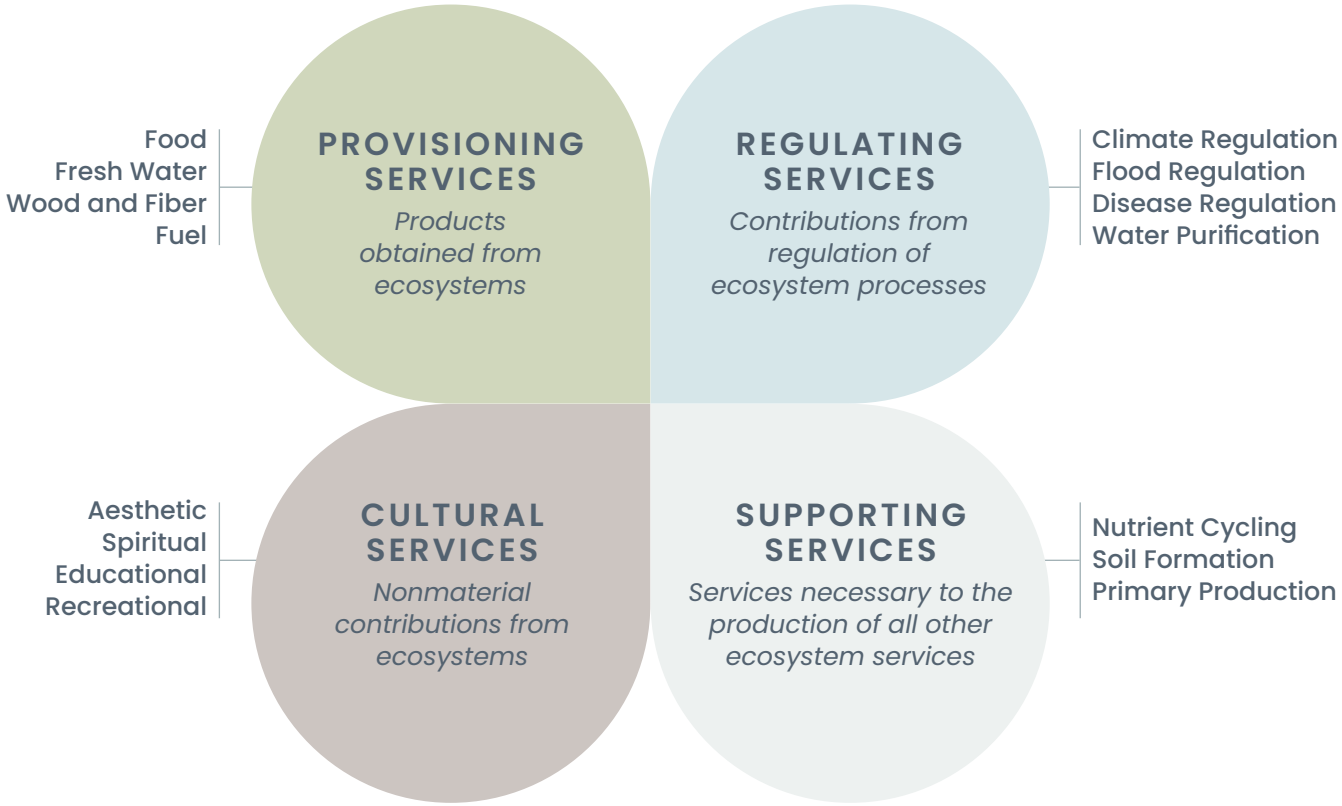
Ecosystem Services



Farms growing a variety of vegetables, including okra, pepper, and eggplant, exhibit improvements in soil quality after transitioning to organic despite different tillage strategies.

valuable. This value was particularly increased by non-market services, which are critical services that consumers don't pay for directly but can still be given a dollar value, like clean air and water, soil fertility, and a lack of pollination. In this study, non-market ecosystem services accrued much more value in organic farms, valued at $460–$5,240 per hectare per year compared to $50–$1,240 in conventional lands. These non-salable services in turn contributed to higher quality crops and yields, providing marketable returns in the long run.

Biodiversity

Boosted ecosystem services on organic farms are often attributed to **increased biodiversity** and wildlife activity. The body of science that demonstrates this theory is vast, and some interesting examples include evidence of better pollination services, which ensures fruit and vegetable production, increased natural pest control that improves produce quality, and more disease control, which ensures competitive yields.

One of the greatest threats to biodiversity is the use of harsh, toxic chemicals in food production. An extensive review of 400 studies, including responses of 275 unique species like earthworms, beetles, ants, and ground nesting bees, found that in 71% of cases, pesticide use negatively impacted soil invertebrates, and pesticides of all types that are currently registered for agricultural use were found to be harmful. The first comprehensive review of its type to explore the direct connection between soil invertebrates and the impacts of pesticides found that by pesticide type, 74.9% of sampled biodiversity were negatively affected by insecticides, 63.2% by herbicides, 71.4% by fungicides, 57.7% by bactericides, and 56.4% by pesticide mixtures. It is clear that to protect the future of biodiversity and our food, the use of toxic chemicals must be reduced, a tenet of organic farming.

Pollination

It is estimated that one out of every three bites of food we eat, including many fruits and vegetables, depends on insect or animal pollination. This essential ecosystem service is bolstered by organic farming, which increases pollinator diversity (different kinds of pollinators) and abundance (greater amounts of each kind of pollinator). The

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absence of pollinators would lead to a catastrophic loss of important vitamins and minerals in our diets, particularly those provided by pollinator-dependent produce crops like tomatoes, apples, blueberries, summer squash, melons, and pumpkins, to name a few.

A study in Europe that assessed the risk of crop losses from spraying harsh chemicals that inadvertently kill beneficial insects including pollinators, estimated a 7% drop in crop production. Conversely, when organic farms use practices that increase plant diversity on their farms, they see a boost in pollinator abundance and success of pollination for crops like strawberries.

Another study on strawberries found significantly higher pollination on organic farms, finding 45% of plants to be fully pollinated in organic conditions compared to just 17% on conventional farms. Organic farming prohibits the use of agrochemicals that are responsible for decreasing pollinator populations, vitality, and pollinating activity through chronic exposure and altering chemical landscapes, and studies like this showcase the protection of biodiversity that organic farming offers.

Ecosystem services on organic farms are often attributed to increased biodiversity and wildlife activity. In the soil, ecosystem services are improved by microbiota and fauna like earthworms, and organic practices create ideal conditions for these organisms to thrive.

Natural Pest Control

Biodiversity is also critical for natural pest control. The many insects that love to eat fresh produce crops can be controlled (eaten) by the variety of animals and predatory insects that organic farms provide safe havens for. For instance, harsh pesticides prohibited in organic production have been associated with decreased bird activity, while bats that eat pests like mosquitoes have been found to prefer organic farms. In New Zealand, researchers compared pest predation rates on different farmlands, examining the rates at which aphid and fake eggs were removed in differently cultivated fields. Predation rates were significantly higher on organic farms, providing at least $35 per hectare per year value on over 85% of fields. No value was gained on any conventional fields from natural predation.

Soil Health and Climate Resiliency

In the soil, ecosystem services are boosted by microbiota and fauna like earthworms, and organic practices create ideal conditions for these organisms to thrive. These species are invaluable nutrient cyclers, maintaining soil structure and fixing nitrogen into forms usable for plants to uptake. Improved soil health ensures a good crop yield, especially in times of extreme weather like drought and flood.

Healthier soil can hold more water and retain its structure in the face of harsh conditions that cause erosion. These qualities are important in times of drought and flooding. Organic practices like crop rotation, crop diversification, and the use of organic soil amendments all improve soil health, and some studies show a major increase in yields for farms under organic management and in times of extreme environmental stress. A long-term research study at Rodale Institute found that yields in organic plots are 40% higher than those in conventional during times of drought.

Pesticides, even in sublethal doses, can inhibit the activity of important soil organisms and create large changes in community structure, curbing their efficacy. For instance, in common beans which have varieties including the popular pinto, kidney, and green beans, microbial symbiosis is lowered in conditions of pesticide application. Beans on pesticide-treated croplands have fewer root nodules, which host nitrogen-fixing bacteria. With more-active microbial communities, organic beans are more productive than their conventional counterparts.

Socioeconomic benefits of organic

Organic is valued at higher prices, brings more income to rural communities

Though not every ecosystem service is marketable, consumers have expressed willingness to pay for the environmental benefits of organic farming. An opinion poll found that participants were willing to pay $147–217 per year for organic farms, when presented with the benefits offered to the local ecosystem. Over 95% of participants valued non-interference with nature, and 94.5% believed farmland ecosystems to be important.

Although organic produce can be more labor-intensive and costly to cultivate than conventional (largely because organic weed management requires hand weeding or special technological solutions instead of spraying herbicides), organic fetches higher prices at farmer's markets and grocery stores. Consumers are willing to pay premiums for the higher quality taste, health perks, and environmental benefits of organic.

In 2023, 15.2% of U.S. produce sales were organic, the highest penetration of the organic market across all grocery sales categories. Organic fruits and vegetables have long been the primary consumer entry point into organic, resulting in steady growth over the past decade. Many studies list price as a barrier towards consumption of organics, however, most consumers show willingness to pay up to 30% more for organic produce, citing health benefits as a rationale for choosing organic.

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To secure our own food supply, we need to ensure that current and next generation farmers are supported well enough to *want* to continue farming. **Organic farming is shown to make farming more emotionally and socially rewarding.**

These price premiums set organic farming up to be more profitable than conventional cultivation—rightfully so given the value of the ecosystem services supported by organic producers. Though organic farms can have lower yields in some farming systems, the higher sale price more than makes up for less product. On average, organic farms would only require a 5–7% price premium to break even with conventional, however median crop premiums are set at 32%. For fruits and vegetables, organic farming is significantly more profitable. This profit soars when accounting for ecosystem services, preparing the land for future use and protecting against drop-offs in yields that may occur due to stagnating soil quality or poor pollination.

Organic farms additionally bring prosperity to local communities. A study examining trends in organic farming "hotspots" (where many farms are clustered together) found those counties to be wealthier. Counties in organic hotspots across the U.S. had higher income per capita and lower poverty and unemployment. When farmers prosper, they can lift other businesses and organizations in their communities with their spending, and when the practices they use also protect local ecosystems and human health, the benefits to local communities grow exponentially.

Organic farmers are happier, more connected to the land

Farming is an emotionally complex vocation, both arduous and rewarding. Farmers are often at risk of mental health struggles due to the poor work-life balance, isolation, and stressful year-to-year economic volatility; though for many, farming is simply their way of life. To secure our own food supply, we need to ensure that current and next generation farmers are supported well enough to *want* to continue farming. Organic farming is shown to make farming more emotionally and socially rewarding.

For instance, a survey of conventional and organic farmers in Michigan found that organic farmers are more connected to the land. Fostering and utilizing ecosystem

83% of young farmers
reported being motivated by environmental conservation.
This means that the next generation of farmers is interested in doing things differently from the status quo of industrialized chemical farming.

services in harmony with cultivation leads these farmers to see themselves as stewards of the land, interwoven with nature. Organic farmers were more likely to express satisfaction in their work and cite community as a driving force.

According to the most recent USDA Census of Agriculture, the average age of a farmer in the U.S. is 58.1 years. Demographically, organic farmers are roughly 6 years younger with higher degrees of education than conventional, and according to a recently published survey from the National Young Farmers Coalition, most young farmers reported that one of their farm's main purposes is stewarding the land and regenerating natural resources. In fact, 83% of young farmers reported being motivated by environmental conservation. This means that the next generation of farmers is interested in doing things differently from the status quo of industrialized chemical farming, and organic farming should help motivate the continued growth of our food production.

Environmental benefits of organic produce production

Organic practices foster more biodiversity

Organic farming limits unwanted exposure to harsh chemicals, which can be harmful or even lethal to plants, animals, insects, and important microbial communities. Pesticides persist in the air, water, and soil following application, creating opportunities for animal consumption and accumulation through the food chain. In general, organic farming has been shown to increase local biodiversity.

Following water contamination either through direct spray or runoff, pesticides and synthetic fertilizers easily enter fish and aquatic invertebrates and threaten their health. A study measuring aquatic invertebrate biodiversity and pollution found that pesticide pollution can reduce species richness (the number of unique species in an ecosystem) by 42%. The species that the researchers identified as "missing" from polluted habitats are known to be especially vulnerable to pesticide contamination. Organic apple production increases species richness by 38% compared to conventional farming, creating the possibility of retaining rich ecosystems while producing high yields.

In the air, pesticides have long lifespans and are often consumed by important pollinators such as birds and bees. A Japanese study found bird populations to be more diverse in organic apple orchards, with many more insectivores. The abundance of insectivores may indicate stronger populations of beneficial insects in organic farms, as past studies have confirmed. Bees, in particular, are responsive to organic practices. In wheat fields, bee populations are larger and more diverse in areas that utilize organic practices. The researchers of this latter study

In general, **organic farming has been shown to increase local biodiversity.** Pesticides persist in the air, water, and soil following application, creating opportunities for animal consumption and accumulation through the food chain.

The soil microbiome—made up of fungi and bacteria— is essential in recycling nutrients into forms that can be readily used by plants. These communities are complex and their structures and dynamics are affected by the addition of pesticides.

project that a 20% increase in organic cropping area could increase solitary bee populations by 60% and bumblebee populations by 150%.

In addition to affecting population metrics, agrochemicals negatively affect pollinator behavior. In birds, sublethal doses of pesticides can reduce vitality. Birds on conventional wheat, maize, and pea farms display less vigor and survivalist behavior than those on organic counterparts. Bee pollination decreases in crop systems sprayed with chemicals. A British study found that the presence of fertilizer spray affected the electrical fields which aid the bees in navigating towards flowers, reducing pollination.

Organic farming maintains and improves soil quality

Soil provides most of the chemical nutrients that plants need to grow. While conventional farming inputs essential chemicals like nitrogen via synthetic fertilizers, organic farmers rely more heavily on ecosystem services and biological additives like compost and manure.

The soil microbiome—made up of fungi and bacteria—is essential in recycling nutrients into forms that can be readily used by plants. These communities are complex and their structures and dynamics are affected by the addition of pesticides. When compared to conventional soil, a Finnish study found the microbial community in organic soils of cereal crops like maize, wheat, and rice, to be much stronger. These soils showed increased respiration, implying higher activity by microbes and increased biomass of microbial communities.

Organic microbial communities aren't just stronger and more active but provide more helpful ecosystem services. An analysis of organic and conventional soils in wheat crops displayed higher quantities of beneficial and disease-suppressive bacteria and increased biodiversity in organic soils. Wheat grown in these soils was more resistant to disease, demonstrating organic soil's potential to substitute pesticides as a disease protection measure.

Beyond nurturing the microbiome, soil quality and structure are improved under

Pesticides used on potatoes hurt soil microbiomes

Conventional potato crops are heavy users of pesticides. Two of the most used pesticides are chlorothalonil and azoxystrobin, fungicides used on 64% and 55% of cropland, respectively. Additional fungicides and chemicals are also applied *after* harvest to prevent potential spoilage and suppress sprouting, especially in long-term storage.

organic farming. Soil organic carbon provides resources for plants and microbes while improving soil structure and reducing erosion and nutrient runoff. Soil organic carbon is higher in organic systems, likely because of carbon integration from applied compost and manure. Additionally, excess synthetic nitrogen results in carbon mineralization, which converts carbon into an unusable form for plants.

Pesticide application can leave residues and byproducts following degradation, which harms plants and microbiota. When plants uptake these chemicals through their roots they experience a myriad of negative effects including DNA damage, photosynthetic blockage, and death. Microbes will have reduced activity, decreased use of enzymes phosphatase and dehydrogenase which are important in nutrient cycling.

Chlorothalonil and azoxystrobin have been found to significantly reduce activity of enzymes that are important for nutrient cycling and intracellular functioning such as dehydrogenases, catalase, acid phosphatase, and urease. When fully functioning, these enzymes improve soil quality and nutrient availability and sustain the microbiome's vitality.

Organic farming improves soil health even with tillage

Tillage is a method used by farmers to rotate the soil, used largely for managing weeds, mixing in soil nutrients, and reducing deep soil compaction. Reduced tillage, also known as conservation tillage, has become a popular farming technique, decreasing the depth of soil rotation to improve soil structure. Reduced tillage and non-chemical-no-till farming serve as sustainable techniques to improve long-term soil nutrients and reduce erosion, and responsible tillage, especially on organic farms, can be beneficial for farmers without being disruptive to the farmland.

Tillage can serve an important role in weed management, particularly for organic

Organic standards require that if certified, organic farmers must: Implement tillage and cultivation practices that maintain or improve soil quality and minimize soil erosion (205.203a), and manage crop nutrients and soil fertility through rotations, cover crops and animal materials (205.203b).

farming. Because organic farms must abstain from herbicide application, weeds are primarily managed manually, either pulled by hand, removed with tools or mechanically with tractor implements. Tilling the soil can uproot weeds prior to planting and serves as a way for farmers to manage weeds early on, reducing labor needs later and improving the success of the crop.

Recently, definitions of agricultural sustainability have been reduced to the discussion of impacts of tilling farmland. The concept of "no-till" has been elevated as the golden standard because less disruption of the soil helps keep carbon locked away and out of the atmosphere, mitigating climate change, and can help keep important soil microbial community intact. However, how land is tilled can be nuanced and reducing the conversation to no-till versus till leaves out a lot of important variables that can have major impacts on the environment. For instance, when no-till is accomplished with the use of chemical herbicides, soil microbial communities are harmed and as soil health decreases, so does the potential to store carbon and to maintain the health of future crops. On the other hand, when conservation, or reduced tillage practices are used, there may be some physical disturbance of the soil, but good health and ecosystem function can be maintained.

In organic farming, building soil health is a fundamental tenet. By definition, organic is an agricultural system managed to foster cycling of resources, promote ecological balance, and conserve biodiversity (205.2) Organic standards require that if certified, organic farmers must: Implement tillage and cultivation practices that maintain or improve soil quality and minimize soil erosion (205.203a), and manage crop nutrients and soil fertility through rotations, cover crops and animal materials (205.203b).

Providing a strong example of the outcomes of organic practices is a 40-year farming system trial conducted by the Rodale Institute. This study has shown that when best practices are used in

organic management, when compared to conventional no-till, organic results in:

- The same or more organic matter and carbon stored in the soil
- Less soil compaction
- Better water infiltration which protects farms against drought and flooding and helps keep toxins out of nearby waterways
- Healthier, more active soil microbial communities, which helps increase nutrient cycling and reduce soil diseases
- The same or better yields

Other studies show that farms growing a variety of vegetables, including okra, pepper, and eggplant, exhibit improvements in soil quality after transitioning to organic despite different tillage strategies. In all soil depths, soil organic carbon increased significantly between the longer the farm was managed organically. However, non-tilled soil had higher levels of soil nutrients including nitrogen compounds and micronutrients like potassium and magnesium ions, in the top layer.

Overall, the decision to till or not to till and what those strategies look like depend on what's feasible for a farmer, but if organic practices are being used, then soil health and quality will be protected.

Organic farming boosts water quality

As pesticide and nitrogen pollution threatens water quality and aquatic ecosystems, organic farming improves water health in nearby areas. Pesticide pollution is widespread in water due to their mass usage and resistance to degradation. In the US, over half of wells and springs contain at least one pesticide residue. A study in the Playa Wetlands—an area of high wheat and corn production—demonstrated high concentrations of pesticide residue due to the agricultural intensification in the area, fluctuating with application periods and weather. Chemicals were at levels unsafe to an estimated 10% of the local aquatic population.

Nitrogen pollution also occurs via leaching, which is more likely after fertilizer application. Fertilizers leave excess nitrogen that is swept into aquatic ecosystems via runoff. An estimated 2–10% of fertilizer

Organic farming improves water health in nearby areas.

Organic management results in better water infiltration which protects farms against drought and flooding and helps keep toxins out of nearby waterways.

nutrients will disrupt groundwaters. These nutrients can cause eutrophication, a type of ecosystem disruption caused by algae overabundance. Nitrate residues in drinking water can be harmful to humans. Contamination is associated with cancer, intestinal problems, and thyroid disease. A study in Iowa revealed organic cultivation of corn, soybean, and oats results in significantly lower concentrations of nitrates and nitrogenous compounds in drainage water and less leaching from the soil.

Organic farming protects air quality

Many pesticides are classified as persistent organic pollutants. Compounds under this classification are both hazardous to human health and difficult to degrade. 15–40% of pesticides are dispersed into the atmosphere during their application. Though they are degraded over time, a recent study found that they last longer than previously thought.

Pesticide drift occurs when airborne pesticide particles travel far from the original application site. This phenomenon is responsible for the health risks incurred by rural communities. In Germany, a study found that pesticides are ubiquitous throughout the country. Researchers set up passive air samplers throughout Germany and detected pesticides at 100% of sites.

Organic farming reduces greenhouse gas emissions, slows global warming

On the farm, greenhouse gas emissions come from several sources, including carbon dioxide emitted by machinery, nitrous oxide emitted by the soil, and methane emitted by animals. Organic practices can reduce greenhouse gas emissions at several sources of output, and even take greenhouse gases out of the atmosphere and integrate them back into the soil to help mitigate climate change.

Nitrous oxide (N_2O) is most commonly emitted by the soil, because of microbial decomposition of excess nitrogen. It is estimated that 17–28% of emissions from maize crops are due to the addition of

Organic practices can reduce greenhouse gas emissions at several sources of output, and even take greenhouse gases out of the atmosphere and integrate them back into the soil to help mitigate climate change.

Boosted carbon sequestration is due to sustainable practices like the usage of cover crops, manure application, and conservation tilling, which provide opportunities for carbonic compounds to integrate into the soil and limit the amount released. These sustainable techniques are highly compatible with organic farming, resulting in fewer weeds and stronger soils.

nitrogen fertilizers. Organic systems, which abstain from synthetic fertilizers, host far less excess nitrogen and have shown reduced nitrous oxide emissions. A study which measured gas flux on organic and conventional corn systems found organic farms to emit 40.2% less nitrous oxide.

Though methane (CH4) emission is primarily driven by ruminant livestock-bacteria inside the stomachs of animals like cows, a large portion additionally evaporates from manure. In organic farming, manure is often used as a natural fertilizer. Its application allows for carbon to be integrated into the soil instead of the atmosphere. Treating maize with manure alone—as opposed to manure and fertilizer—dropped manure-sourced methane emissions to an insignificant level.

Carbon sequestration is the mechanism by which atmospheric carbon compounds become integrated into the soil as soil organic carbon. This process both slows global warming and builds healthier, more nutrient-rich soil. A meta-analysis of soil carbon contents following organic conversion found that switching to organic cultivation significantly increases soil carbon stocks for the first decade. Boosted carbon sequestration is due to sustainable practices like the usage of cover crops, manure application, and conservation tilling, which provide opportunities for carbonic compounds to integrate into the soil and limit the amount released. These sustainable techniques are highly compatible with organic farming, resulting in fewer weeds and stronger soils.

Organic practices have been found to reduce greenhouse gas emissions by a significant margin. In the US, a 1% increase in organic and conventional farmlands is associated with a 0.06% and 0.13% increase in greenhouse gas emissions, respectively. In the United States, a 1% increase in organic farming could reduce national greenhouse gas emissions by 0.05%.

Conclusion

Organic can work on any farm regardless of scale, crop type, and diversification

Regardless of the shape and size of an organic farm, they are all required to meet at least the minimum organic standards, which are designed to improve the health of the environment and people.

Organic standards have been scientifically demonstrated to:

Reduce human health risks. Organic produce has higher levels of essential antioxidants and nutrients including flavonols, phenolic acids, and vitamin C. Organic produce also reduces dietary exposure and on-farm occupational exposure to synthetic agrochemicals used in conventional farming, which can cause negative health effects and developmental issues. Pesticides can be absorbed through the skin, respiratory system, and digestive system, leaving many pathways to exposure when these persistent pollutants are near. Organic farming practices that eliminate the use of these agrochemicals can reduce disease risks for farmers and local communities.

Improve biodiversity. One of the greatest threats to biodiversity is the use of harsh, toxic chemicals in conventional food production. Organic farming systems, which prohibit these toxic synthetic chemicals, demonstrate increased biodiversity and wildlife activity, including better pollination services, which ensure

fruit and vegetable production, increased natural pest control that improves produce quality, and more disease control, resulting in competitive yields.

Improve soil health. In the soil, ecosystem services are boosted by microbiota and fauna like earthworms, and organic practices create ideal conditions for these organisms to thrive. These species are invaluable nutrient cyclers, maintaining soil structure and fixing nitrogen into forms usable for plants to uptake. Improved soil health ensures a good crop yield, especially in times of extreme weather like drought and flood. A long-term research study at Rodale Institute found that yields in organic plots are 40% higher than those in conventional during times of drought.

Reduce greenhouse gas emissions and energy consumption. On the farm, greenhouse gas emissions come from several sources, including carbon dioxide emitted by machinery, nitrous oxide emitted by the soil, and methane emitted by animals. Organic practices can reduce greenhouse gas emissions at several sources of output, and even take greenhouse gases out of the atmosphere and integrate them back into the soil to help mitigate climate change.

Organic produce is a better choice for consumers, farmers, and the environment. No matter what you value—protecting your health and the health of your family, ensuring farmers and farmworkers have safe working environments and livable wages, or environmental sustainability and combating climate change—organic is the answer.

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